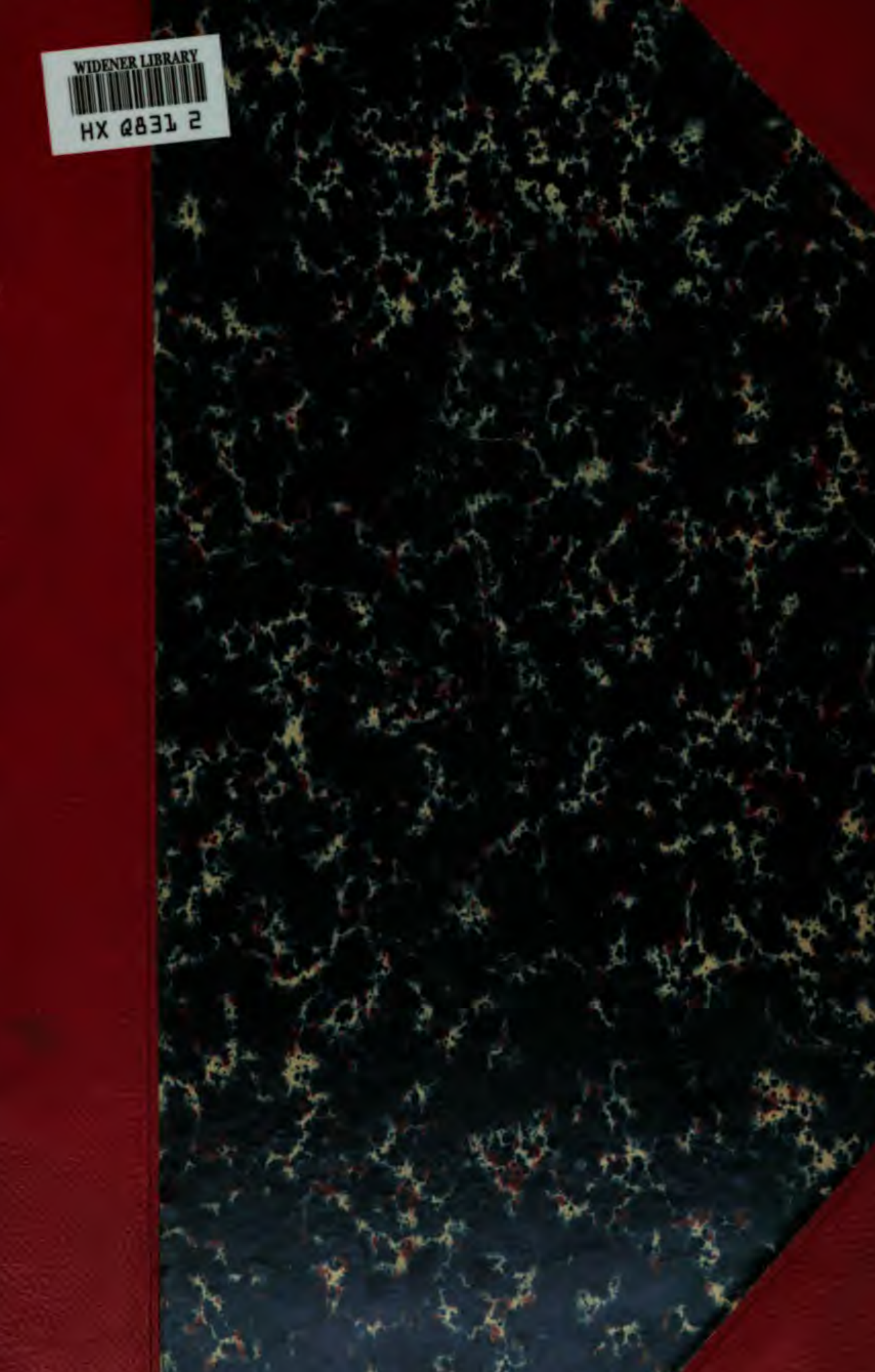
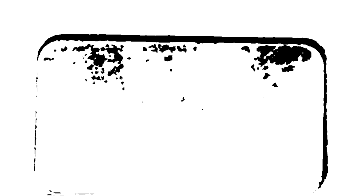

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DEVOTED TO THE PUBLICATION OF THE RESULTS OF RESEARCH
BY MEMBERS OF THE UNIVERSITY OF KANSAS.

SERIES A.—SCIENCE AND MATHEMATICS.

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TABLE OF CONTENTS.

No. 1.

No. 2.

No. 3.

No. 4.

KANSAS UNIVERSITY QUARTERLY.

VOLUME VIII. 1899. SERIES A.

INDEX.

Vol. VIII. JANUARY, 1899 No. 1.

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KANSAS UNIVERSITY QUARTERLY.

VOL. VIII. JANUARY, 1899. NO. 1.

The Coccidæ of Kansas.

Contributions from the Entomological Laboratory, No. 64.

BY S. J. HUNTER.

With Plates I to VII.

The Homopteran family, Coccidæ, in many respects anomalous and in others similar, is unique in the diversities of the sexes and the modes of distribution. Sex and genus necessarily present differences. The variations existing within a single species, and gradations between species, however, have proven of peculiar interest. It is with these specific differences in view that the studies upon this group have been prosecuted. It is believed that from a large series of discriminations interesting deductions might be made.

The manner of preparation and method of study of this group have occupied some time. I will endeavor to give briefly an outline of my observations and experiments upon the technique of the genera mentioned in this paper. The first work was done with the usual bleaching reagent, a strong solution of potassium hydrate, washed in water, transferred to fifty per cent alcohol, then to ninety-five per cent alcohol and from here to a clearing mixture composed of two parts by measure of carbolic acid crystals and three parts of rectified oil of turpentine, taken from this to slide and mounted in xylol-balsam. The difficulties found in this process were: dangers of boiling too much or of not boiling enough, specimens had to be removed while the liquid was warm else a deposit would collect upon them and render them useless, material was generally more or less macerated and frequently the plates were not retained throughout the process.

Another means used was to soften the specimens in warm water then transfer to fifty per cent alcohol, then to ninety-five per cent alcohol, from here through the clearing mixture into balsam. This I found better, in that it insured the retention of the plates present but it had the objection of not rendering old and heavily chitinized scales transparent.

For a new bleaching agent, chloral hydrate, saturated solution, boiling specimens in this under cover for a few moments and also by leaving in the fluid under cover for twelve to twenty-four hours. The latter method—leaving in for a day or less—gave the best results, rendered the specimens transparent and kept them reasonably firm. It did not appear to affect the plates and spines; did not leave any undesirable substances upon the specimens. From the chloral hydrate they were taken into the water and then through the process previously described.

In experimenting with the action of xylol upon the plates it was found that it rendered them very brittle and left them undesirably transparent, so that in some specimens mounted in xylol-balsam I noticed a tendency to render the plates of the same refractive index as the balsam. Glycerine as a mounting medium was tried, and it was found that specimens could be more readily taken from a chloral solution into glycerine than by any other method used. The objection to the glycerine is, of course, that permanent mounts require to be incased in cement. Glycerine jelly, I think, will largely overcome this difficulty, and I expect to test it in my subsequent work.

Having the mounts ready for study I found daylight not always the most satisfactory light for revealing the points desired, so that the light of the Welsbach burner passed through a liter balloon flask, filled with a solution of copper sulphate, rendered the desired clearness by the addition of ammonia (NH_3), the test being a white light thrown upon the reflector. This illuminating apparatus is spoken of in *Botanisches Practicum*, Strasburger, 1897, and *Microscope and Microscopical Accessories*, Zeiss, No. 30, 1895. Mr. McClung, of the department of Zoology, in his work tried the addition of a drop or two of saturated alcoholic solution of saffron to the fluid in the flask. This I consider advantageous; enough being added to give the light a tinge of pink, which gives good contrasts with the yellow subject. I had endeavored to find a stain that would hold in firmly chitinized specimens, but met with little success. This pink light, showing the necessary contrast, as it does, served the same purpose at a great saving of time and labor.

The microscope used is the C. Zeiss, Jena, stand 1a, with complete equipment. The objectives used on triple nose piece are low power B, high power F, and oil immersion 1-12 inch, N. A. 1.22. Though I have tried an Abbe camera lucida, I prefer to make the sketches free hand.

Aspidiotus forbesi Johns. Plate I, Figs. 1, 2, 3, 4, 5; Plate II, Figs. 6, 7.

The scales of male and female in this group, brought together from widely separated localities, conform to the description.

Lots A, B, C, F and E show distinct tendency to congregate in groups and then others mass upon these. Lot G, though on old cherry trees, were few in number and only to be found upon one or two spots in three adjacent cherry trees. Lot F was most abundant upon the old bark of the trunk of the apple tree. Bark of apple tree frequently pitted. Lots D and E appeared to be distributed more nearly over the bark. Of this group the following numbers of mounts of each have been studied: eight, of A; ten, of B; nine, of C; four, of G; ten, of D; seven, of E; four, of F; making in all fifty-two individuals, these agree with "Plates inconspicuous or absent, spines prominent," but differ uniformly in number of spines.

There is in each lot, spine on median lobe agreeing with description, *but another spine appears extending over the margin from the dorsal side*, one beside the "second" and one beside the "third" spine, making a pair of spines, one on the ventral and one on the dorsal side, instead of one spine at "second" and "third." This was so in all cases and in this respect they agree with *ancyclus*. The chitine at the incisions appears to be uniformly heavier than shown in the original sketch. Lot D presents the greatest variations, as shown by sketches. Another form, which is very suggestive of another species, appears on same branch among this lot D. More material will be required before this point can be satisfactorily determined. The second lobe is notched, agreeing with Professor Cockerell's observation, but the larger chitinous process between first and second lobe is less twisted than shown by the same author. (Tech. Ser. No. 6, Div. Ent., pp. 6 and 8.) The scale is found upon trunk and branches. More abundant upon heavier limbs. I have found it upon the twigs and in and around the terminal buds of twigs.*

*Since the above was written I have found this scale upon cherry and apple in Anderson county and upon cherry and apple in Franklin county. In Franklin county a plot of five acres of apple stock being cultivated for scions, was so generally infested by this scale that it was deemed advisable to uproot the whole plant. A large cherry tree near by was also condemned. The scions cut this fall from the apple plot will be subjected to gas treatment before being used.

Forbesi was first reported from Kansas by Prof. E A. Popenoe in *Kansas Farmer*, locality not given, reference to which is made in my Bull. Dept. Ent. Univ. Kans., *Scale Insects Injurious to Orchards*, p 24, Jan., 1898.

Lot A, on cherry, Lawrence, common, taken January 28, 1898.
Lot B, on cherry, Seward county, taken February 18, 1898.
Lot C, on cherry, Cloud county, taken March 12, 1898. (No sketch.)
Lot G, on cherry, 2½ miles northwest of Lawrence, taken October 18, 1898.
Lot D, crab apple, Lawrence, taken April 4, 1898,
Lots E and F, apple, Lawrence, taken April 5 and 20, 1898.

Aspidiotus ancyclus Putnam. Plate II, Figs. 8, 9.

Common on maple. In this species, as in the most of the *Aspidiotus* I have observed, there is a marked tendency to segregate. Clusters of scales sometimes two and three deep are to be found while comparatively few scales are situated alone. While this is doubtless true to a greater or less extent in all, it seems to be more noticeable in this species. And further that the scales meet upon the cephalic margins. Number of specimens of 3b studied, 12. The contour of anal plate of 3a and 3b agree. Second lobe depressed. Differences and locations of spines and plates are shown in the accompanying drawings.

The circumgenitals in 3b exceed the limits given for the species. Caudo-laterals 7 to 10, cephalo-laterals 13 to 19, anterior 0 to 4. 3b differs from 3a further in the chitinization of the incisions, 3a agrees with original figure in having the chitine nearly evenly distributed over the incision, almost crescent shaped, 3b shows the chitine along the sides of the incisions and incisions clear at bottom. 3b shows more dorsal glands, and this was characteristic of this group.

Common on maple in and around Lawrence.

Aspidiotus uvæ Comst. Plate III, Fig. 10.

On grape vines. No marked variations apparent. Iola, Kansas, February 12, 1898.

In June Mr. P. J. Parrott sent the writer specimens on grape from Manhattan.

Aspidiotus uvæ Comst. var. Plate III, Fig. 11.

Scale of female convex, circular, reddish white, red largely due to cork cells present, scale resembles *uvæ* somewhat; *uvæ* arranges itself in rows; this insect has no special mode of arrangement. Exuviæ slightly laterad of center, covered with white secretion; when this is removed orange colored exuviæ appear. Scale 1½ mm. in diameter.

Scale of male. Elongate, broad and roundly convex anteriorly and flattened posteriorly. The outline of margin of scale is egg-shaped, broad end at anterior margin, exuviæ covered with white secretion, nipple and ring fairly distinct. When rubbed rather large orange colored exuviæ appear. Exuviæ situated between the highest point and anterior margin, sometimes on anterior margin. Length 1 mm., width about ½ mm.

Female. Body circular, lemon yellow with many irregular deep orange spots, the greater number along the caudal margin of the penultimate segment. One pair of lobes notched on lateral margin, some specimens show lobes one entire the other notched. Approach each other at distal extremity, well chitinized, especially so along mesal margin near base. Two pairs of incisions with chitinized processes.

Plates forked, two caudad of each incision. One spine on median lobe, a pair laterad of each incision, and another pair about same distance laterad of second pair, as exists between first and second pair of spines, the third pair of spines are not as near to each other as the spines of the other pairs are. Five groups of ventral glands, numbers shown on figure 11. Nine mounts of females studied and many scales.

A further discussion upon this variety will be given subsequently. A comparison between a good series of the *Carya uvæ* with a series from *vitis* Sign. is desired. The exact status of this variety may then be better set forth.

On *Carya alba* Nutt. Lawrence.

Aspidiotus osborni Newell and Ckll. Plate III, Figs. 12, 13.

Since original description is not at hand for comparison I will add the following notes:

Scales rather evenly distributed over the branches of the tree. Scales slightly raised in center, depressed around margin. Color dirty gray, yellowish on top caused by exuviæ showing through, oval, 2 mm. by 1½ mm. Exuviæ laterad, covered by white secretion, when rubbed orange colored exuviæ appear; ventral scale white, very delicate.

Scale of male. Elongate oval, sides almost parallel. About 1½ mm. in length. Darker than female. Exuviæ laterad, lemon yellow when whitish secretion is removed. The scale is slightly raised along its greater median line, depressed at margin.

Female. Oval, lemon yellow. One pair lobes, median, showing slight notch on distal margin and faint notches may appear on lateral margin. Chitine appears to extend cephalad from base of lobes, mesal margins show chitinous processes.

Two pairs of incisions, each bearing chitinous processes on sides, processes nearly equal in size but rather wide apart.

Plates inconspicuous, one or two caudad of second incision, small. Spines prominent, one on lateral margin of median lobe, two between first and second incisions upon what might be considered a depressed lobe. One spine laterad of second incision and another spine half way between the fourth spine and a pair of spines on the lateral margin. Another spine appears on lateral margin near penultimate segment. (Not shown in figure.)

Four groups ventral glands, caudo-laterals 4 to 5, cephalo laterals 4 to 6.

From many scales and mounted specimens.

Nymph. Leg, antenna, and caudal margin shown by Fig. 13.

On *Quercus alba* L., Douglas Co.

Aspidiotus ulmi Johns. Plate III, Fig. 14.

Found in two localities in the city of Lawrence upon catalpa, massed upon the branch of the tree. In an entirely different locality upon *Ulmus fulva.* It seemed in each case to be of long standing. Many old scales were found covered by the outer cork layer.

The scale of female agrees quite well with original description, except that I would not call the scale "quite convex;" slightly convex suits here better. Male scale agrees with description.

Mature female differs from original description and figure in having two notches upon the mesal margin of the lobes. In some specimens the proximal notch is faintly marked. The drawing made from the type shows here a slight curve.

The thickening of body wall as shown in original description is quite characteristic of specimens examined. In an examination of twenty mounted specimens no circumgenital glands were found.

Aspidiotus fernaldi Ckll. subspecies **albiventer** subsp, nov. Plate IV. Figs 15, 16.

Abundant on the trunk from the ground up. When the tree is wet the exposed ventral scales stand out almost like fine flakes of snow.

In the orange exuviæ, and in the mode of congregating and shape of scale, this insect favors *ancyclus.* The color of the scale is lighter and the structure of the female precludes the possibility of its being *ancyclus.* The Putnam scale prefers the branches, this scale the trunk. I have been unable to find a species described in the liter-

ature that agrees with this scale, so I have offered the following description:

Scale of female, grayish white, strongly resembling bark of maple, in clusters, ventral scale well developed, the white substance annulated, scale circular, somewhat convex with the cephalic margin extended, beyond the circumference, exuviæ cephalad of center covered by white secretion, when this is removed large dark orange red exuviæ appear. Scale 1½ to 2 mm.

Scale of male elongate oval, about ½ mm. in length, ventral scale well developed, but not arranged in rings, color of dorsal scale somewhat darker. Exuviæ between center and cephalic margin, covered by white secretion, showing faint trace of dot and ring, when this removed orange red exuviæ appear. These exuviæ are much smaller than exuviæ of female scale.

Adult female, obovate, dark orange in color. There are three pairs of lobes. The median lobes are prominent, notched on lateral margin, line of mesal margin extends parallel with line of meson. Chitinous processes at inner base of lobes.

Second lobe pointed, erect, outer margin ranges from smooth undulating line to a margin bearing three distinct notches. This variation is shown by series of sketches (Fig. 16, a, b, c, d,). The third lobe is also erect, ranging from inconspicuous to long, slender, round lobe with notch (sketches Fig. 16, a, b, c, d,).

There are two pairs of incisions, with chitinous processes; these chitinous processes remain constant. A large club-shaped process on median side of first incision, a smaller one just opposite. The process in second incision approaches a crescent.

Plates are present, one or two inconspicuous caudad of first incision, always simple, one or two caudad second incision, generally forked. There is generally one simple plate between median lobes.

Spines, one on first lobe, usually two laterad of second lobe, the same may be said of the two situated laterad of third lobe. Another pair of spines are always present on the lateral margin between the third lobe and the penultimate segment.

There are five groups of ventral glands; caudo-laterals range from 5 to 8, cephalo-laterals 10 to 12, anterior 2 to 6. From many scales and mounted specimens.

The trunk of the maple bearing these scales was densly populated. Lawrence, Kans.

Aspidiotus obscurus Comst. Plate VI, Fig. 25.

On black oak *Quercus tinctoria?* Bartram. Douglas Co., Kans.

Aspidiotus juglans-regiæ Comst var. Plate IV, Fig. 17.

Scale of male, oval, elongate, 1 mm. in length, raised anteriorly, flattened posteriorly, darker than female, exuviæ situated near anterior margin, covered with white secretion, ring and dot within distinctly seen upon exuviæ.

Scale of female, diameter less than 3 mm., not more than $2\frac{1}{2}$ mm. Ventral scale "mere film," "adheres to bark." Color and position of exuviæ agree fairly well.

Female. Color pale yellow with "irregular orange colored spots." Oral setæ and last segment dark yellow. Number of circumgenitals do not agree with description, as shown by my drawing.

Lobes three, three pair present, pointed, plates "simple, inconspicuous," "resemble spines," the largest found caudad of each incision. Some specimens show simple plate between median lobes.

Incisions shown in figure. Mesal bases of median lobes slightly chitinized. Spines agree, except that on median lobe I find a spine not shown or mentioned by Comstock

Spines. First spine on mesal lobe, a pair between first and second incision, a third pair laterad of third lobe. This pair is also about half way between the median lobe and fourth pair of spines.

Plates inconspicuous, arranged as shown in drawing, one between median lobes, one cephalad of first incision, two cephalad of second incision, all simple.

Circumgenital glands, five groups, variable, extremes found are caudo-laterals 2 to 12, cephalo-laterals 8 to 13, anterior 0 to 5. Chitinized clubs present along side glands as shown. From ten prepared specimens of females and many scales of male and female.

On one young crab apple tree. Lawrence.

A comparison between this species and the original description:

Juglans-regiæ var.	**Juglans-regiæ**, as described by Professor Comstock, on p. 300, plate XIV, Agr. Rep. of 1880.
FEMALE.	FEMALE.
Lobes two, and also a third pointed prominence, not to be called a lobe.	Two lobes and a third pointed prominence.
Median lobes vary in outline, some being more elongated than others. Well developed.	Well developed median lobe, varying in outline.
Second lobe about one-half as large as median lobe.	Second lobe less than one-half as large as median lobe.
Second lobe has three notches on lateral margin, in all cases.	Second lobe with one or two notches on lateral margin.
Two pairs of incisions, small but made conspicuous by chitinization.	Two pairs of incisions, small but made conspicuous by chitinization.
A chain-like incision extends cephalad from first incision.	No mention.
Plates simple and inconspicuous, resembling spines in form. Larger ones are one caudad of each incision.	Plates simple and inconspicuous, resembling spines in form. Larger ones are one caudad of each incision.
Spines prominent.	Spines prominent.
Short spine on median lobe.	No mention.
Two spines laterad of second lobe, both on ventral side.	Description does not say how many; drawing shows one on dorsal and one on ventral side.
Two spines laterad of third prominence, both on ventral side.	Drawing shows a pair; one spine on dorsal and cne on ventral side.
Pair of spines one-third of distance from median lobe to penultimate segment. Two spines on ventral surface near lateral margin of penultimate, and two on ante-penultimate segment.	Fourth spines are nearer median lobe than to the penultimate segment.
Anterior glands 3 to 5, anterior laterals 9 to 11, posterior laterals 9 to 10.	Groups 4 or 5 in number. Anterior consisting of from 1 to 4, anterior laterals of from 7 to 16, posterior laterals of from 4 to 8.
MALE.	MALE.
Antennæ, nine jointed including basal joint. Wing expanse about 2 mm.	Not described.

Aspidiotus perniciosus Comst. Plate IV, Fig. 18; Plate V, Figs. 19, 20, 21, 22, 23.

The variations in the anal plate of female are greater than in any of the specimens of any species studied. In fact it was the exception to find one specimen having the structure of the two sides identical. The relative size of the chitinous processes between the first and second lobe remained the same, "close together and of nearly equal size," but these rarely ever appeared under the microscope at same focal point—that is, the relative sizes of the two could be gained only by focusing up and down. Dorsal glands uniformly few in number, small plate just laterad of second incision always present.

A large number of individual mounts have been studied and sketches of many made to illustrate their structures.

The scales of this group are uniformly dark, in many cases black, the white secretion covering the exuviæ of male is scant, in some cases almost wanting, leaving the black sculptured ring and dot, resembling description of *A. andromelas.* Others, however, have the dot and ring fairly well marked.

The anal plate of female has presented many interesting features. Fig. I may be considered as an extreme. Very few indeed show the forks in plates so marked as they appear at a. This figure farther shows two plates caudad first incision, serrate, in this the specimen is normal. The irregularly shaped plates present on left side at b, between spines four and five, and absent entirely on right has been frequently observed. This figure further shows the inconspicuous plates between the median lobes. Their absence in some specimens examined could be satisfactorily explained by their being broken in course of preparation.

Fig. II may be taken as an average, shows only one plate caudad of first incision and this plate forked.

Laterad of spine four is another spine; this is unusual. Between spines four and five (not counting incidental spine) are two irregular plates on right and three on left.

Fig. III represents a left side of one specimen and a right side of another transposed and placed beneath for illustration of variations in structure of the two sides.

Figs. IV and V represent other individuals studied.

Newly born nymph. This agrees with description given by Howard and Marlatt in every respect save one. Their description reads: "The large central plates each terminate in a long hair." In the twenty nymphs examined the long hairs are not connected

with the plates, but arise from the ventral surface of the body cephalad of the plates and extend out under the plates caudad.

On a pear tree brought from New Jersey. Location near Argentine, Kans.*

Aspidiotus greenii Ckll ‡ Plate VI, Fig. 24.

In the old scales found at base of palm leaf the exuviæ are nearly black, scale grayish black.

The plates found between the median lobes are in some cases forked. There is also a variation of two in the number of toothed plates. In some there are two more upon a side than in others. The greatest number of toothed plates found on a side was six, simple plates constant at four. Their relative position as well as the number and position of the spines is best shown by the figure.

Fifteen mounted females studied, and many scales. Found massed at base of palm leaves and extending a short distance up the leaf.

On the palm, *Howea belmoreana*, in green house. Lawrence, Kansas.

Aspidiotus hederæ Vall. var. **nerii** Bouche.‡ Plate VI, Figs. 26, 27; Plate VII, Figs. 28, 29.

Scale of female and male agree with description. Position and condition of first and second skin of female as described.

Female, light yellow in color mottled with yellow.

The anterior and posterior lateral glands agree with numbers given, but in two specimens out of the twenty-five studied I find in the one case a pair of glands forming an *anterior group*. In another specimen I find an *anterior group* of two with one lying between this group and the right anterior lateral group. This I have shown in the sketch. This group of glands, not spoken of by Bouche or Comstock, is of interest. The plates and spines agree satisfactorily with the description. The comparatively small number bearing this anterior group may be the reason why this group, probably observed,† is not mentioned in the original descriptions.

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*This tree was bought three years ago, when two years old, from Parry's Pomona Nursery, Parry, N. J. It was placed at northwest corner of a young orchard. It has been rooted up and burned. The writer visited this orchard on Dec. 10, 1898, and gave the grounds a careful examination; two small colonies of about a dozen individuals each were found on two trees adjacent to place where infested tree stood. These have been cut away, and the owner, a progressive horticulturist, intends subjecting all the trees in that part of the orchard to a thorough treatment with whale oil soap wash as an extra precaution.

†I was unable to find reference in literature to median group in *Aspidiotus* s. str. I wrote Prof. Cockerell concerning my observation and asked for reference to such a group. He finds that Berlese examining *Aspidiotus hederæ* var *limonii* in Italy found *one* example with one gland representing the median group. Cockerell adds interestingly: "The appearance of a median gland thus is probably an atavistic feature, as the supposed ancestors of *aspidiotus* s. str. (*Diaspis*-like types) probably had the five groups."

‡As may be inferred from the host, these species are not indigenous.

Found massed on oleander leaves, much more abundant on under side than upper side. Atchison, Kans.

Aspidiotus æsculi Johns. sub. sp. **solus** sub. sp. nov. Plate VII, Fig. 30.

Female scale circular, 2½ to 3 mm. in diameter, flat, dark in central part, dirty gray around margin. Texture of scale light; one side will adhere to the bark while the other side being loose will curl up over, scale translucent. Exuviæ laterad of the center, sometimes on margin, covered with light secretion, easily rubbed off showing light orange exuviæ. Ventral scale almost invisible to the naked eye.

The plates of the female agree in the main with *ancyclus*, the contour of the anal plate resembles the same species, notably the depressed second lobes. The scale presents differences which preclude a consideration of *ancyclus*. The scales are much scattered and are situated singly. Upon seven twigs averaging three inches in length, all chosen from the tree because they bore scales, the following numbers of scales appear on each in the order examined: four, two, three, five, one, one, two. On the twig bearing three, two of them were about one-fourth inch apart, the others were more remote from each other.

The male scale favors *forbesi* in color, but the description of *juglans-regiæ* in shape.

Mature female. Light yellow, one pair of median lobes, notched midway of lateral margin, lobes in some converging, in others the inner line of lobe is straight or slightly divergent. Two pairs of chitinous processes on each side, club-shaped. From the pair just laterad of the median lobes there extend cephalad U-shaped openings in the body wall.

Plates prominent. Caudad of first pair of club-shaped processes is a plate generally forked, between first and second pair processes there are from none to three plates, caudad of second pair processes are one or two plates.

There is a spine near lateral margin of lobe, a pair of spines between the two pairs of processes, a pair of spines just laterad of second pair of processes, another pair one-third distance from lobe to penultimate segment, a single spine a like distance from the penultimate segment.

Five groups of circumgenital glands, caudo-laterals 6 to 9, cephalo-laterals 9 to 14, anterior 0 to 2. Club organs around glands, in some cases obscuring the anterior group.

From ten satisfactory mounts and many scales. On *Juglans nigra* L. University campus.

Through the kindness of Professor Cockerell I have received some of the original material from which *æsculi* was described. I have compared the two species as follows:

A. sub. sp. **solus** compared with	A. **æsculi**, taken from the original material.
Scales of *solus* uniformly darker	than scales of *æsculi*.
Color of exuviæ of *solus* lighter	than exuviæ of *æsculi*.
Texture of scale very delicate.	Texture firm.
Scale flat.	Scale slightly convex.
Margin of scale irregular and frequently indistinct.	Margin of scale distinct.
Broad median lobe notched once on lateral margin; lobe bears spine.	Same.
Laterad of lobe is an incision bordered by club-shaped thickenings.	Laterad of lobe is an incision filled with chitine forming a crescent-shaped structure.
Line of U-shaped openings extending cephalad in body wall from the incision.	Same.
Caudad of incision one forked plate.	Same.
Laterad of this incision from two to five plates.	Laterad of this incision never more than two plates.
Laterad of median lobe on last segment are three pairs of spines, each pair composed of one spine from each side of the body wall, then a single spine near penultimate segment, making in all seven spines on lateral margin of the segment.	Only three spines on lateral margin of last segment and all arising from ventral surface.
Laterad of first incision is a second incision but little smaller than the first; the sides of this bear club-shaped chitinous processes.	The body wall at this point is entire and no additional chitine is apparent.
Dorsal glands numerous.	Dorsal glands numerous.

Five groups circumgenital glands. Caudo-laterals 6 to 9, cephalo-laterals 9 to 14, anterior 0 to 2. (Majority of specimens show 1 or 2 glands in anterior position.)

Four groups circumgenital glands. Caudo-laterals 8 to 11, cephalo-laterals 9 to 14, anterior group wanting.

The fifth group of glands, greater number of plates and spines, and additional well chitinized incision on margin of anal plate, together with peculiarities of the scale, are differentiations worthy of consideration in forming a specific separation. I prefer for the present, however, to place *solus* as a sub species, and have allied it to *æsculi* on account of similarity in contour of margin of anal plate of female. Later I hope to be able, with *A. juglandis*, *A. juglans-regiæ*, var. *pruni*, var. *albus*, var. *kafkæ* and *A. æsculi* before me, to establish the exact position of *solus*.

Mytilaspis pomorum Bouche.

The scales longer than measurements given in description, being 2½ to 3 mm. Structure of female conforms with typical forms. Found upon the outer branches of two apple trees in one locality. Lawrence, Kans.

Diaspis snowii, nov. sp. Plate VII, Figs. 31, 32, 33.

Scale of female. Flat, oval, 2 by 3 mm., exuviæ laterad of center on the shorter axis. Scale sometimes more nearly circular and more regular in outline, then exuviæ appear to be located nearer margin. Margins ragged. Central portion of scale dark gray, pallid on border, scale very flat approaching margin so that the connection between scale and bark is not readily discerned. A very delicate ventral scale.

Scale of male. White in fresh specimens, orange white in older specimens, 1 mm. long, narrow, rounded longitudinally, but slightly carinated. Exuviæ orange yellow, terminal. Some specimens not quite so long and broader. The mature male has not yet been observed.

Female. Oval, lemon yellow. Anal plate extended but little beyond the general shape, orange, well chitinized. Anal orifice situated at base of aperture between median lobes.

Circumgenitals, five groups, caudo-laterals 5 to 9, cephalo-laterals 8 to 15, median 0 to 2.

One pair lobes, notched on outer margin, two incisions on each side showing chitinous processes.

There is a spine on or near the lateral margin of the lobe, one between the first and second incisions, one laterad the second incision; the fourth spine is as far from the third as the third is from the median lobe. There is a small spine at a distance from the penultimate segment equal to distance between the second and third spines. On ventral margin of penultimate, and on each of the two segments cephalad, there are a pair of small spines. The rest of the body bears a spine on the ventral margin at somewhat irregular intervals.

Plates prominent, not quite as long as the spine, two caudad first incision, one or both forked, one forked plate caudad second incision and two plates, generally simple, between the incisions. Several rudimentary plates laterad second incision.

From eleven satisfactory mounts and many scales of both sexes.

On *Salix nigra* Marshall. Douglas Co.

This species belongs to the subgenus *Epidiaspis* Ckll. MS., the type of which is *D. piricola* Del Guercio. The number of glands in the median group of *snowii* are less than in *piricola*, The glands of all groups are much less in number than in *D. pyri* Colvée. A distinction of moment is the extreme posterior position of anal orifice as in *Diaspidiotus*. This orifice is well cephalad upon the last segment in *piricola*, being located between the caudo-lateral groups of glands. The median lobes of this species show distinct notch about midway upon lateral margin, *piricola* is entire.*

It is highly fitting that this interesting representative of a European group, the first Coccid to be described from this laboratory, be dedicated to Chancellor F. H. Snow, whose persistent and untiring labors in the field of Natural History are largely responsible for the present status of biology in the University of Kansas.

My sincere gratitude is due Professor Theo. D. A. Cockerell for material encouragement and valuable suggestions kindly offered in the pursuit of these studies. I wish to express my appreciation of the assistance of Mr. P. A. Glenn, a student of this department last year, in the acquisition of the material here studied, and to acknowledge the earnest and careful work of Miss Ella Weeks in her part of the delineations accompanying this article.

The genus *Lecanium* is now under consideration and it is expected that a discussion of the Kansas forms will appear in a later number of the KANSAS UNIVERSITY QUARTERLY.

Author's Edition, published December 17, 1898.

*For comparison between *D. piricola* and *D. pyri*, see Bull. Div. Ent. Tec. Ser., No. 6, p. 4, Cockerell.

The Characters of Bison occidentalis, the Fossil Bison of Kansas and Alaska.*

BY F. A. LUCAS.

With Plates VIII, IX.

In studying the fossil bison of North America it has become evident that the specimen from Kansas described as *Bison antiquus* by Mr. Alban Stewart, is of a totally distinct species and identical with a specimen from Fort Yukon, Alaska, collected by Sir John Richardson, and now in the U. S. National Museum. The name *Bison occidentalis* was proposed for this species in a paper read before the Biological Society of Washington, and noted in *Science* for Nov. 11, 1898, on page 678. As there described the characters of the species, as indicated by the horn cores, are as follows: Horn cores of moderate size, although much larger than in the existing species; circumference at base equal to, or slightly greater than length along upper curve; sub-cylindrical in section and regularly curved upward and backward; type No. 4047, U. S. National Museum. The diagnosis of the species was based on the horn cores, because in almost every fossil bison these are the only parts available, and it was important to have the diagnosis of all species founded on the same set of characters. The cranium from Fort Yukon was taken as the type because it was the one actually handled, although the specimen from Kansas is of course by far the more complete example.

As *Bison occidentalis* has been confused with *Bison antiquus* a comparison of the two is necessary. *Bison antiquus* was founded by Dr. Leidy on an imperfect horn core from Big Bone Lick, Kentucky, now in the Academy of Natural Sciences, Philadelphia, and the name has since been applied to almost every specimen of fossil bison that has come to light. An examination of the type of *Bison*

*In this QUARTERLY of July, 1897, pp. 127-135, Mr. A. Stewart, of the department of Paleontology, gave a description of a nearly complete skeleton from the valley of the Smoky Hill river in western Kansas, referred to *B. antiquus* Leidy. The able and thorough studies of Mr. Lucas, on the Bisons of North America, have made it apparent that the species was really a new one. He has kindly sent the present article, descriptive of it, for publication in the QUARTERLY.—S. W. WILLISTON.

antiquus shows that the striking characteristic of the species is that the horn cores stand out at right angles to the longitudinal axis of the cranium, so that a line drawn across the back of the cranium completely misses them. *Bison antiquus* is thus the only species of North American bison whose cranium will stand squarely on its occipital region, as in all other species the horn cores rake backwards and project beyond the back of the skull. It is further distinguished by the fact that the tips of the horn cores barely rise above the level of the plane of the forehead, a feature shown in the uppermost figure of plate XVII, illustrating Mr. Stewart's paper. It may here be said that after comparing the cranium from California, named *Bison californicus* by Mr. Rhoads,* with the type of *B. antiquus*, it has been impossible to discover any differences between them, so that *B. californicus* must be considered a synonym. The horn cores of *Bison antiquus* contrast with those of *B. occidentalis* in being proportionately shorter, more abruptly conical and stouter, the horns of the latter species more nearly approximating those of *Bison bison*, although of course being much larger. The salient cranial differences between *B. occidentalis* and *B. bison*, such as the greater length of the cranium in the fossil species, and the larger, more pointed nasals have been pointed out by Mr. Stewart, and are shown in the plate accompanying this article.

So far but two species of fossil bison have been found in Alaska, *Bison crassicornis* Richardson and *Bison occidentalis* Lucas. The former of these has never been found outside of Alaska, and is apparently confined to the more northwestern part of the territory. Consequently it is not improbable that its affinities are with some Siberian form, and that, like *Ursus middendorfi* and *Ovis dalli* it represents an influx from Asia. *Bison occidentalis* appears to be more nearly like the existing *Bison bison*, and from the conditions under which the Kansas specimen was found seems to have been co-existent with man and possibly with the existing species of bison as well.

*Proc. Acad. Nat. Sci., Phila., 1897, p. 501.

A Preliminary Description of the Opercular and other Cranial Bones of Xiphactinus Leidy.

Contribution from the Paleontological Laboratory, No. 40.

BY ALBAN STEWART.

With Plates X, XI.

In the museum of the University of Kansas there is one specimen of *Xiphactinus* that has the opercular bones in almost complete condition, and another partially so. As these bones, with the exception of the preopercular, have never been described from complete specimens I think it will be well to give a short description of them with figures. The catalogue number of the specimen under consideration is 88.

The opercular is a broad, flat plate of bone, near the anterior superior portion of which there is a deep elliptical pit for articulating the bone with the hyomandibular. This pit is projected rather outward from the rest of the bone, very closely resembling the corresponding portion of *Saurodon* in this respect. Just above this pit there is a sharp angular projection at the point where the anterior and superior borders meet, but I am inclined to think that this character will not be constant in all specimens. From this point the superior border extends backward and downward in an irregularly curved line to the lower border, which is less curved and somewhat striated just above it. The anterior border, extending from the articular portion just mentioned downward, is nearly straight and somewhat thickened. Back of this border the bone is very thin, thus making it difficult to collect in perfect condition.

The preopercular is a somewhat triangular-shaped bone with a very thick and concave anterior border. The lower portion of this border is directed forward at quite an angle and is received in a slight groove on the back portion of the quadrate. Extending

backward from the extremity of this portion there is a row of large, shallow foramina, the posterior ones of which have shallow grooves leading into them from behind. Below this line of foramina the bone is not so thick, and is covered with numerous fine striæ.

The superior portion has a rather broad process extending upward, formed by the anterior and superior borders The posterior portion of the bone is thin and striate on both sides of the upper portion.

The bone figured by Cope* and described by Crook† as an interopercular I am inclined to think is not an opercular. bone but one of the cerato-hyals. I have found a bone very similar to this between the lower jaws of a specimen of *Anogmius* (*Beryx*) *polymicrodus* Stewart, and another, somewhat different though bearing a general resemblance to it, between the lower jaws of a specimen of *Ichthyodectes*. With this evidence at hand, there can be but very little doubt of its being a cerato-hyal. The bone is elongated and in outline is somewhat the shape of a parallelogram with one side crushed in. The posterior end is the broader of the two and bears an elongated, narrow and concave facet for the epi-hyal. The anterior end is more irregular in outline and bears two facets for the hypo- and uro-hyals. The bone is thin and finely striated throughout.

There is still another opercular bone, which I regard as a subopercular. The bone is broad and flat, thin along the borders and thickened toward the central portion. The posterior extremity is the broader of the two and is somewhat rounded. The anterior end is much more narrow and bears a small elliptical facet on a slight elevation of the bone. It also presents a beak-like process, separated from the above by a slight depression. Both the external and internal sides are striated, the striæ becoming very pronounced near the posterior end of one of the sides.

Measurements of the opercular bones:

Opercular; length of anterior border	373‡	mm.
" length of anterior border below the facet for the hyomandibular	268	"
" length of facet for the hyomandibular	55	"
" transverse width of facet	22	"
Preopercular; greatest length	345‡	"
" width near superior extremity	80	"
" width of inferior end	170‡	"

*Cret. Vert. West., pl. XL. fig.
†Paleontographica, 1892, p. 117.
‡Estimated.

Subopercular?;	total length	290	"
"	width across anterior extremity	90*	"
"	with across posterior extremity	146*	"
Cerato-hyal;	greatest length	238	"
"	width across anterior end	86	"
"	width across posterior end	97	"

There are four other bones, some of them are fragmentary, that I have never seen figured or described before;† figures of which are shown on plate XI. They were all found in connection with the skull, and evidently belong to it, with the probable exception of one. The first of these, Figs. 1 and 5, is an elongated bone, expanded at one end and contracted into an elongated, narrow, and somewhat thickened process at the other, at the extremity of which there is a roughened surface which probably gives attachment for cartilage. On one side of this process there is a long, thin lamina of bone, extending toward the extremity and so closely applied to it that at first sight it has the appearance of being the border of a groove on the edge of the process. The expanded end is thickened and bears a small articulating surface, the face of which is almost in line with the process mentioned above.

The second of these, Fig. 2, is represented by portions of two bones. These are thin on one side while the other is much thicker and has a shallow grove, formed by an overhanging ridge of bone. This thickened portion was probably continued outward in a process beyond the rest of the bone. The third, Fig. 3, is plate-like and more or less sculptured on both sides. On one of the sides there is a broad, triangular-shaped depression, which is invaded by a notch from the edge of the bone, and on the side there is a prominent ridge extending away from the apex of this notch. I have found a bone almost identical with this in connection with the opercular of an unknown fish, which evidently does not belong to the *Saurodontidæ*, and with this fact in view it must be referred to this genus with doubt The fourth and last of these bones, Fig. 4, may be an infra-opercular. It is the largest of the bones under consideration, and is very thin and flat, excepting on one of the sides, where it suddenly thickens into a prominent ridge, which probably continues to the border. The bone is finely striated on both sides.

Lawrence, Kas., Jan. 6, 1899.

*Estimated.

†Since the above article has gone to press I find that two of the bones described above, plate xi, figs 1, 3, and 5, have been figured by Prof. Cope, Cret. Vert. West., pl. XL, figs. 4. 4a, and 8. The last of these is called an "uncertain bone," and the first a "Hyomandibular," which, of course, is incorrect.

Diphtheria in Kansas.

BY MARSHALL A. BARBER.

With Map.

In the preparation of this paper the following sources of information from Kansas were used: The State Board of Health Reports from 1886 to 1897 inclusive, the United States Census Report of 1890, letters received from county and city health officers in various parts of the state, and special letters regarding certain outbreaks. Data from other localities for the purpose of comparison were obtained from the work of Dr. Thorne Thorne entitled "Diphtheria, Its Natural History, etc.," treating of the disease in England and Wales, the statistics of the United States Census of 1890, the publications of the Health Boards of Denver and Kansas City, Mo., and the Board of Health Reports of various states, especially of Massachusetts and Michigan, and the Reports of the District of Columbia. Other reports, correspondence and the like furnished further information. I found the information given in the Kansas Health Reports very meager, and in many of the reports so little pains has been taken to classify and tabulate the data that it is necessary to consult each county report separately. In the reports of 1896 and 1897, for instance, the tables of vital statistics are taken from the assessors' reports, and cover the years ending March 1, 1896, and March 1, 1897, respectively, instead of the years ending December 31, 1896, and December 31, 1897, which the reports are supposed to cover, thus making the information given useless for comparison with other years. Each year several counties fail to report, and the reports when sent are often incomplete; so that it is not safe to rely too much upon them. On the whole, the statistics given in the State Reports are such that only the most general conclusions can be founded on them.

Letters were sent to all, or nearly all, of the organized county boards of health, and to the city boards of a number of the largest cities of the state, asking for information on phases of the question not covered by the reports to the state board. A blank was enclosed to be filled out asking the opinion of each health officer,

based on his observation in his own county, on the effect of sanitary environment, of wealth or poverty, of locality, of meteorological conditions and of certain articles of food on the origin and spread of diphtheria. About forty-five answers were received from various parts of the state. These answers seem to me to be of considerable value, not only for the information given in regard to diphtheria, but because they give us some idea of the opinions held by the health officers of the state in regard to this disease. It is to a great extent the duty of these officers to take measures to prevent outbreaks of infectious diseases and to control epidemics, and it is of value to know on what they base their judgment in this work. I have, therefore, given considerable attention to these letters.

The information obtained has been classified as follows, and will be taken up in the order given: Age, sex, color, season, meterological conditions, topography and geographical location, sanitation and some other agents which may affect the spread of epidemics.

As to the influence of age on diphtheria, little information could be obtained from the records of this state, and this information is, perhaps, of little value; for there is no reason to think that the ages of greatest mortality are any different in Kansas from what we find in the records of other states and countries. In the report of an epidemic in Wichita in 1891, the average age of fatal cases was given as 5.4 years. In the United States Census Report for the year ending May 31, 1890, it is reported that 196 of the total 385 of deaths from diphtheria in Kansas during that year occurred under five years, and the largest number, 58, was given for the second year of age. Out of 259 deaths from croup during the same year, 209 occurred under five years. In Michigan the average age of fatal cases in a four year period ending in 1894 was 8.4 years. In the Massachusetts reports it is stated that the greatest incidence in that state is on the period 0 to 5 years; in England and Wales Dr. Thorne puts it on the age period 3 to 12 years.

There is no information in our reports on the influence of sex on diphtheria, except during the years 1886 to 1890 inclusive. During these five years 453 deaths are reported in which the sex is specified; and of these 244, or 53.86 per cent, are males and 209, or 46.14 per cent, are females, a difference of 8.72 per cent. Averaging the school population during these years, it is found that 51.4 per cent are males and 48.6 per cent are females, a difference of 2.8 per cent. If we can trust these reports, therefore, it is shown that the disease was slightly more prevalent among males than females during that period.

Dr. Thorne found that in England and Wales there is a greater prevalence of diphtheria among females, and he ascribes this to the more domestic habits of girls and the resulting greater liability to contact with the sick. In the Massachusetts reports, covering the years from 1856 to 1897, the death rate per 10,000 of population from diphtheria alone was 5.26 for males and 5.29 for females. Diptheria and croup combined gave males 8.70 and females 8.13. In the United States Census Report for the year ending May 31, 1890, there is reported 164 fatal cases of diphtheria among males and 221 among females in Kansas. Croup and diphtheria combined gave males 245 and females 349. In the entire United States during that year 13,514 males and 14,301 females died of diphtheria alone, and 21,033 males and 20,644 females of croup and diphtheria combined. It is evidently impossible to generalize safely from the above figures in regard to the influence of sex on diphtheria in Kansas or in the country at large.

As to the incidence of diphtheria on colored people as compared to white there is little information in the state reports. In the Wichita epidemic referred to above it is reported that there were no cases among the colored people. The city physicians of Lawrence, Leavenworth, Ottawa and Topeka informed me that in their opinion diphtheria is less prevalent among colored people, and Dr. J. A. Mitchell, of Kansas City, Kas., wrote me that he does not remember of a case among colored people in twenty years' practice. In brief, all evidence from physicians in this state agreed that colored people are less susceptible to this disease than white.

When we come to compare data from other sources we find that in Alabama during the census year 1890 65 deaths from diphtheria occurred among the white population, which form 0.63 per cent of the deaths from all causes among the white people; while 15 deaths are reported for the colored race, which is only 0.14 per cent of the total mortality among the colored people. In the entire country the mortality due to diphtheria during the same year was 3.5 per cent of the total number of deaths among the white population, while in the colored it was only 0.79 per cent. In a district including the metropolitan district of New York, with its cities, the state of New Jersey, the District of Columbia, and the cities of Baltimore, Boston and Philadelphia a record of the deaths during the six years ending May 31, 1890, shows that during this period the mortality from diphtheria and croup combined among the white people was 5.5 per cent of the deaths from all causes, while among the colored people it was only 1.5 per cent. In the records of the

District of Columbia alone a much smaller difference is shown. During a fourteen years' period, ending in 1897, the deaths from diphtheria and croup averaged annually 0 57 per 1,000 among the white people, and 0 52 among the colored people.

As regards the incidence of diphtheria on the different months of the year only three of our reports give any definite information, and this is summarized in table I, given below.

TABLE I.

	Jan	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct	Nov.	Dec.
1897...	15	13	11	7	3	2	6	5	13	29	12	10
1898	16	6	9	8	17	11	5	3	16	15	17	12
1899	14	9	8	5	4	3	2	6	12	12	16	10
Total.... ...	45	28	28	20	24	19	13	14	41	56	45	32

It is seen from this table that the month of highest mortality is October, and the lowest July; and the months from September to January, inclusive, show a much higher death rate than the rest of the year. One cannot safely generalize on so little evidence, but it may be noted that the results agree substantially with those of other localities in this latitude. The Health Reports of Kansas City, Mo., for 1898, so far as they have been received, agree in the main with the above table; and the statistics of the city of Denver during the years 1897 and 1898 show the highest mortalities during the months of October, November, December, January and April, and during an eleven year period, ending in 1896, the highest rates are in January, February, March, May, October, November and December. It may be of interest to compare reports from localities having a very different climate. The Pacific coast states during the census year 1890 show the highest diphtheria mortality in the months of January, September, November and December. According to the Health Reports of the state of Florida there was a total of fifteen deaths from diphtheria during the three years 1891, 1893 and 1894; these are distributed by months as follows: January, three; March, three; October, two; November, four; December, two; all other months none. Massachusetts and England and Wales agree with the above localities in showing the greatest mortality during the first and fourth quarters of the year. It will be noted that these localities all agree in having their coldest weather in the first and fourth quarters, and that there is not much else common to all that could have an influence of diphtheria. In some the season of greatest rainfall comes in the winter, in others in the spring and early summer months; while the periods of vacation

and school attendance, which may have much influence on the spread of epidemics, are not the same in this country and in England.

Since our reports give so little information in regard to the monthly mortality of diseases, it was impossible to determine whether there was any relation between the meteorological conditions of a given month and its death rate from diphtheria. In table II of this article the yearly mortality of each of the twelve years is compared with the average rainfall, the mean annual temperature and the relative humidity. It is obvious that such a comparison is of much less value than a comparison by months; since the distribution of certain kinds of weather in the year may be of much greater influence than the average amount. However, a brief summary of the meteorological data of this table will be given for what it is worth.

If we take the years 1889, 1891, 1892, 1895, 1896 and 1897, in which the diphtheria death rate is reported to be equal to or above the average, we find that in four of the six the annual rainfall was above the average, and in all except 1892 and 1895 the relative humidity was above the average. The temperature was above the average in three, and of these three two show a rainfall below the average. An examination of the meteorological data of each month of the years 1887, 1888 and 1889, in which the monthly mortality from diphtheria is given in our reports, leads to nothing further than the general conclusion that there is less diphtheria in the warmer months of the year.

In the blank sent out to the county and city boards of health in this state the following questions was asked: "What meteorological conditions seem to favor the prevalence of diphtheria? In particular what is the effect of very dry seasons or of cold, wet weather in early autumn, such as we had last October?" Of those who answered this question, twelve were of the opinion that cold, wet weather favors the prevalence of diphtheria, three of them putting emphasis on cold, wet weather out of season. Two mentioned cold, dry weather, one of these stating that such weather may favor a more malignant type of the disease. One had noted the occurrence of an epidemic in warm, wet weather in early spring, and another was of the opinion that cloudy, wet weather with temperature just above freezing induced the disease. Four mentioned wet weather without making any statement in regard to temperature, and one, cold weather, without mentioning the humidity. Other opinions were: drouth, one; sudden changes, one;

snows in early winter, one, and one mentioned the probability of a greater dissemination of germs in dry weather. Five had seen no connection between meteorological conditions and the disease. It is seen from these reports that the greater number believe that both cold and wet weather favor the prevalence of diphtheria, but there is by no means a unanimity of opinion in the matter.

There seems to be a still greater difference of opinion in regard to the effect of dampness of locality. Fifteen believed that nearness to streams and bodies of water, and damp surroundings in general, favor the occurrence of diphtheria; while fifteen others had noted no influence of such environment on the disease.

When we come to compare the death rate in different localities in this state and in other states, and consider the question from the point of view of geographical location and climate, we get additional light on the influence of topography and weather. For a summary of the mortality in different counties of this state the reader is referred to the map accompanying this article. The data for this map were all obtained from the State Board of Health Reports, and cover the years from 1886 to 1897 inclusive. The uppermost figure in each county gives the total number of deaths from diphtheria reported during the twelve years. The lower figure gives the average annual death rate per 1,000 persons of school age. This rate was obtained by dividing the total number of deaths reported from a given county during the twelve years by the number of years in which the county has given a classified report of the deaths from infectious diseases, and this result was divided by the average number of thousands of persons of school age in the county. The figures from which the average population was estimated were taken from the reports of the superintendent of instruction, and all the years from 1886 to 1896 inclusive, were averaged. The 1897-98 report was not at hand, but an estimation showed that the population in 1897 does not vary enough from the average to make a material difference in the result. The school population was used instead of the total population because the figures were more accessible, and in the study of a disease prevailing largely among children, the school population forms a fair basis of comparison. Besides, the school population bears a nearly constant ratio to the total population when we average a considerable number of years. The fact that the annual average was obtained by dividing the whole number of cases by the number of years the county reported, instead of by the entire twelve years, explains why two counties reporting the same number of cases and

having approximately the same population may show a very different average death rate. The evidence in the reports in regard to croup was so uncertain that it was not taken into account, and all figures refer to diphtheria alone.

The broken lines running across the map pass through points having approximately the average annual rainfall in inches indicated by the numbers at the ends of the lines. The rainfall of the area between any two lines varies between the numbers indicated on these lines. These lines are taken from a map prepared by Prof. E. C. Murphy of Kansas University.

The evidence furnished is so incomplete that it is impossible to arrive at any but very broad generalizations. According to the reports scarcely more than six counties have given a report of the deaths from infectious diseases, specifying the number from each disease, in all of the twelve years; and an average taken of eighty-four counties already organized in 1886 shows that these counties have made such reports on an average of 7.8 times instead of twelve. Besides, the reports when made are incomplete in many, if not in a majority of cases, and the difficulty of determining the number of times a county has made a specific report on infectious diseases adds somewhat to the uncertainty of the results. It was sometimes hard to distinguish a report of no deaths from a failure to report on the subject.

But if the results are unreliable for a given county, it is still possible to arrive at conclusions when we compare certain large portions of the state with others. It is observed at once that the western part of the state shows a much smaller mortality, on the whole, than the eastern; and this is especially noticeable in the southwestern counties. A few of the western counties show a very high death rate. In the very small average population of these counties one or two deaths add much to the rate per thousand, and, since some of these deaths may be among transients or recent arrivals, it does not necessarily follow that conditions favorable for diphtheria prevail in these localities because the death rate is high. It will be observed that the southern tier of counties shows, as a whole, a smaller mortality than the northern. This is true if we take all the counties in the tiers, or if we average only the seven eastern counties of each.

The evidence of the reports that the western counties have comparatively little diphtheria is to some extent confirmed by the letters of correspondents. Writers from Greeley, Seward, Stanton, Sherman and Wichita counties report that to their knowledge no

deaths have occurred in their counties during periods ranging from six to thirteen years; and Clark, Ellis, Ford, Ness, Pratt, Stafford and Stevens counties report a marked freedom from the disease. Correspondents in some of the eastern counties, too, report that very little diphtheria is known in their localities, but there is a larger proportion of such answers from the western part of the state.

When we come to compare the conditions which surround these different portions of the state, we find that the west, especially the southwest, has the least rainfall; the elevation is greater there, and in general there is better drainage. In the southern tier of counties the rainfall is probably as great as in the northern, and evidently greater in the eastern seven than in the corresponding counties of the northern tier. Density of population is certainly a factor influencing the death rate in an infectious disease, and especially in one that is so often spread by crowded school-rooms; and the sparsity of population, without doubt, partially explains the freedom from diphtheria which seems to be enjoyed in the western part of the state. The average density of population in the seven eastern counties of the southern tier, however, is probably as great as that of the corresponding seven of the northern tier; since the southern has about 58 per cent of the combined school population of the fourteen counties averaged for the twelve years, while the northern tier has 42 per cent. This difference will nearly make up for the greater area of the southern group.

In this connection we will compare statistics of localities outside of the state. In the city of Denver the average death rate of diphtheria and croup during an eleven year period, 1886 to 1896 inclusive, is 93.45 per 100,000 annually. In Massachusetts during the years 1876 to 1895 inclusive, the rate from diphtheria and croup combined was 96.4 per 100,000, and for diphtheria alone it was 72.2. In Michigan during the ten years, 1885 to 1894, the rate of diphtheria alone was 46 88 per 100,000. In the District of Columbia in the fourteen year period, 1884 to 1897, the rate of diphtheria and croup among the white people averaged 52.5 per 100,000. So we see that the death rate of diphtheria in Denver, where the elevation is great and the rainfall and humidity low, is not much less than that of Massachusetts, and exceeds that of the District of Columbia.

For further comparisons of state with state, I have only the record of the one year ending May 31, 1890; but this is of some value when we compare large groups of states. In Grand Division

A of the Census Report, including the New England states, New York, New Jersey and Pennsylvania, the mortality from diphtheria and croup was 4.9 per cent of the deaths from all causes. In Grand Division B, including Delaware, the District of Columbia, Florida, Georgia, Maryland, the Carolinas and Virginia, the mortality was 3.0 per cent of all deaths. In Grand Division C, including Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee and Texas, the deaths from diphtheria and croup were only 2.9 per cent of all. In Grand Division D, including all the remaining states, exclusive of the Pacific states, the mortality was 6.2 per cent. In the Pacific states, Grand Division E, the mortality was 3.8 per cent. It is seen from these figures that the mortality from diphtheria is comparatively high in the northeastern, the middle, and the northwestern states, lower in the milder Pacific region and lowest of all in the southern states. Averaging the states Colorado, North Dakota, South Dakota, Idaho, Montana and Wyoming, where the rainfall is not great, the elevation high and the climate relatively cool, the proportion of deaths from diphtheria is rather high, averaging 5.3 per cent. If we average the south Atlantic and Gulf states, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Texas, we find the proportion only 0.77 per cent. If we can trust these figures the conclusion seems to follow that a cool climate favors the prevalence of diphtheria more than a warmer, and the degree of humidity is probably a factor of less importance than the temperature. The hygienic conditions of the northwestern states mentioned is probably as good, or better, than that of the Atlantic and Gulf group, and the population is certainly more dense in the latter.

Taking into consideration this collateral evidence, we may say that the presumption is strong that diphtheria is more prevalent in the northern part of Kansas than in the southern, and that this is due, partly, at least, to the difference in temperature. For the partial immunity enjoyed by the western part of the state, sparsity of population, dryness, better drainage and greater elevation are possible explanations; but whether all of these are concerned in the problem or not, and what the relative weight of each factor is, the evidence is hardly sufficient to decide.

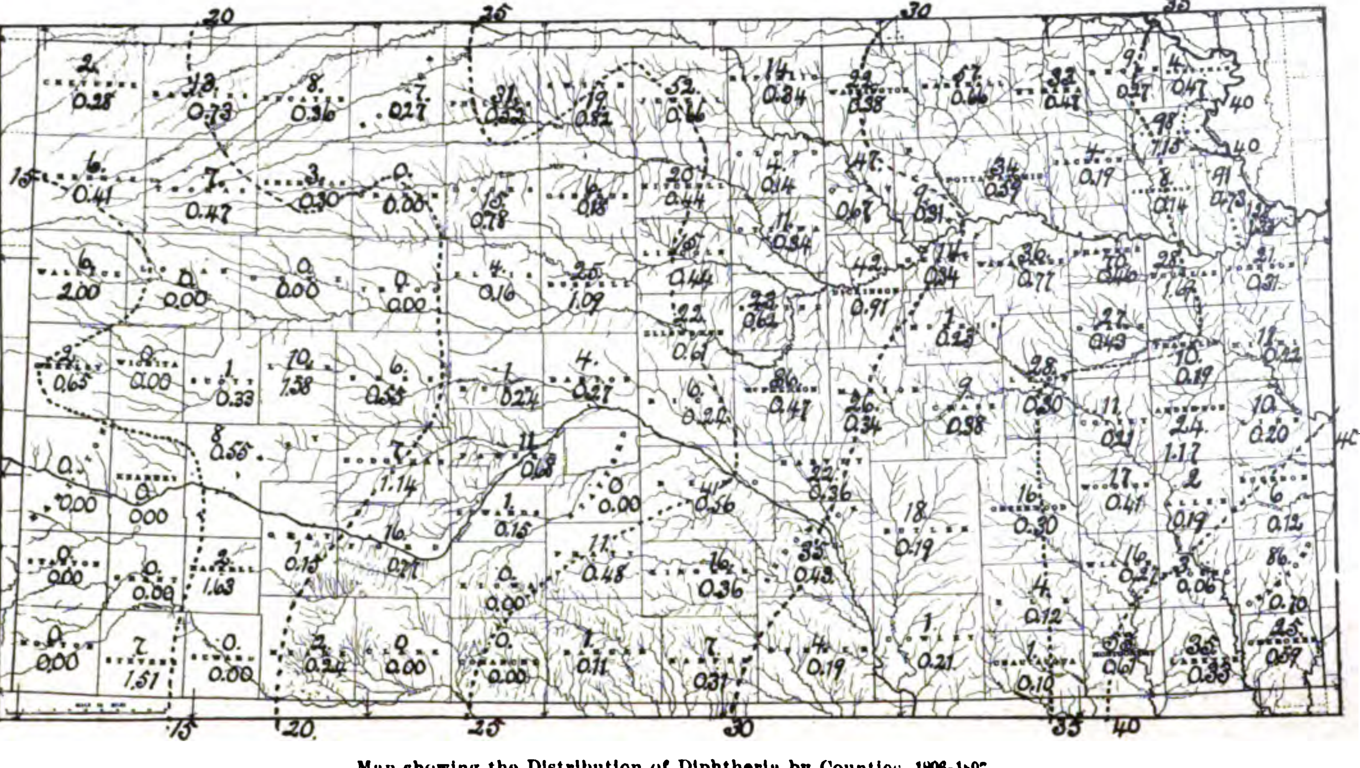
As to the influence of sanitation on diphtheria there are some letters in the State Reports, one of which I will mention, that of Dr. P. W. Barbe, of Oswego, Kansas, given in the 1892 report. In answer to my letter of inquiry, Dr. Barbe kindly wrote me further information and

confirmed the statements given in his report to the State Board. In Oswego, in 1892, an epidemic of diphtheria broke out among the school children. The school ground was divided into two parts, one occupied by the boys and the other by the girls. The water supply for the boys was furnished by a hadrant and that for the girls by a well that had been allowed to become foul. Only a portion of the girls used the well water because it smelled and tasted bad, and close investigation showed that all of the thirteen cases of the epidemic were confined to the girls who drank water from the well, and that about 90 per cent of those who used the water were taken ill with diphtheria. The epidemic broke out within ten days after the school began and there had been no diphtheria in the town previously. The epidemic was of a mild type, and after the well was cleaned there were no further cases.

The opinions expressed in the letters of the county and city health officers of this state agree almost unanimously that bad sanitary surroundings of various kinds increase the liability to diphtheria. Four mentioned bad drainage and sewerage; eight, bad water; six, damp or foul cellars under dwellings; four, crowded houses; seven, poor ventilation. Other influences which were mentioned were: lack of sunlight, overheating a poorly ventilated and filthy room for some days, burning of leaves within the city limits, and well water from sandstone. A number mentioned bad sanitation in general without specifying any particular sort. The influence of bad sanitation in causing sore throat and thus predisposing to diphtheria was also mentioned. Scarcely more than one of those who gave any opinion in the matter stated that no relation had been observed between bad sanitary surroundings and diphtheria.

The question was also asked whether the poor are more liable to diphtheria than the well-to-do. Nineteen were of the opinion that the poor are more liable, and of these twelve specified that the greater liability is due to poor sanitary surroundings. Fourteen thought that there is no special incidence on the poor, and two or three stated that in their opinion the rich are more subject to the disease. Four mentioned "dug-outs" and sod houses as rendering the occupants more liable to diphtheria.

In the letter of inquiry it was also asked whether any spread of epidemics had been observed to be due to raw milk or any other article of food. Two mentioned poor food in general as favoring diphtheria, and a city physician suggested that the kind of fruits often sold on the streets by Italian venders might be agents in the



Map showing the Distribution of Diphtheria by Counties, 1896-1897.

spread of the disease; but the answers were for the most part negative. As to agents other than food, one or two correspondents suggested domestic cats, and there is a case of this kind described in the 1886 report by Dr. Isaiah Miley, of Phillips county.

A decrease of the death rate of typhoid fever so uniformly follows improvement in drinking water and sanitation in general that the amount of decrease may be taken to measure roughly such improvement; so in estimating a possible relation between sanitation and diphtheria it is of value to compare the diphtheria and typhoid death rates during a series of years. Dr. Thorne remarks that with the improvement in the sanitary condition of London during the years 1871 to 1889, accompanied by a decrease in infectious diseases taken as a whole and a very marked decrease in typhoid, there was a decided increase in the diphtheria death rate. Statistics from other localities show that the decrease of typhoid due to better sanitation is not followed by an equal decrease in diphtheria. This is true whether cities or countries are taken as a whole, or whether certain districts, specially improved in sanitation, are compared with unimproved districts in the same city. The evidence available in this state is presented in the following table compiled from our health reports:

TABLE II.

YEAR.	Diphtheria.		Typhoid Fever.		Average rainfall in inches.	Mean temperature in degrees.	Humidity.
	Total number of deaths reported.	No. per 1,0.0 persons of school age.	Total number of deaths reported.	No. per 1,000 persons of school age.			
1886........	90	.18	149	.30	24.25	52.06	66.5
1887........	123	23	224	.43	33 84	53.12	69 8
1888........	138	.26	255	.48	44.17	52.28	72.2
1889........	264	.50	188	.35	43.99	53.57	73.2
1890.......	60	.12	52	.10	36.32	54.10	73.8
1891...	165	.83	138	.28	43.32	52.60	79.0
1892..	160	.32	393	.79	42.34	52.26	81.0
1893.... ...	108	21	307	.61	34.71	52.80	.....
1894.......	145	.29	269	.54	30.01	55.81	64.1
1895........	313	.63	362	.73	47.16	53 34	68.1
1896.	218	.44	235	.47	34 87	55.11	72.9
1897.......	164	.32	201	.39	23.34	54.37	72 3
Average..	162	.32	231	.46	36.53	53.49	72.1

According to this table there has been no marked decrease in the death rate of either diphtheria or typhoid, except during the last three years of the table, when the total amount of typhoid decrease has been slightly greater; and there is nothing in the table, taking

the period as a whole, to warrant the conclusion that there has been a diminution of infectious diseases, or an improvement in sanitation in the state. In view of the general uncertainty of our statistics it is impossible to tell whether a low death rate recorded for a certain year indicates unusual good health on the part of the people, or an unusual neglect to report on the part of physicians and health officers; and the table is of value only if we assume that the amount of neglect is proportionally about the same every year. From the figures in this table the average annual death rate in Kansas during the twelve years from diphtheria alone was 1.17 per 10,000 people of all ages. If we had a complete record of deaths we would probably find this far beneath the actual rate. The United States Census Report gives 385 as the number of deaths in Kansas from diphtheria during the year ending March 31, 1890, while in the State Board Reports we find only 324 given for 1889 and 1890 combined.

An attempt to gain accurate information in regard to any disease in this state impresses strongly on one the need of better vital statistics. Many diseases are known to be to a great extent preventable, and in an intelligent attempt to control any disease it is important to know its previous history in the state, its strongholds and the conditions which surround them and the effect of varying seasons on its prevalence. Knowledge of the history of a disease in a state is as important for its prevention as the history of a disease in an individual is for its cure. The state of Michigan publishes each year, for every county in the state, the number of localities attacked by diphtheria, the number of cases, the number of deaths and the death rate, besides data showing the points of origin of epidemics and the direction of spread, while in Kansas we hardly know whether the disease is increasing or not in the state as a whole. In our agricultural reports we have statistics showing the number of dogs in the state and the number of sheep killed annually by dogs and wolves, yet we have no vital statistics from which we can learn with any accuracy how many children yearly die from diphtheria. The entire blame for this state of affairs cannot be laid on the health officers of the state and counties; it is only when the funds needed for their work are given them, and when they receive the aid of all physicians and the moral support of the people in enforcing the law, that we may hope for material improvement in this important work.

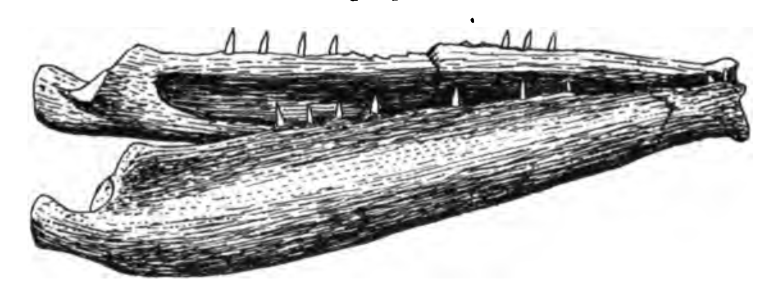
I wish to thank Dr. H. Z. Gill, secretary of the state board of health, and the county and city health officers of this and other states for valuable assistance in the preparation of this paper.

Pachyrhizodus Minimus, a New Species of Fish from the Cretaceous of Kansas.

BY ALBAN STEWART.

Contribution from the Paleontological Laboratory No. 41.

While collecting with the Kansas University Geological Expedition last summer I was fortunate enough to find a specimen of *Pachyrhizodus* from the Butte Creek region in Logan county, Kansas, that is much smaller than any of the species heretofore described, for which I would propose the name of *P. minimus*.



Lower jaw of *P. minimus*, twice its natural size.

The specimen consists of the mandibles only, which are characterised as follows: The dentaries are slender and slightly incurved at the symphysis where they also seem to be bent slightly downward. The symphysis is bifurcated by a deep groove on the external side but internally it is continuous from above downward. On the external side there is a shallow groove just below the alveolar border, which becomes indistinct toward the symphysis. The lower border of the bone is sharp and nearly straight, and the external side is deeply grooved as in *P. leptognathus*. There are eleven teeth preserved upon one of the rami and room for at least as many more. They are conical, non-striated and directed inward; the last is situated quite a distance from the coronoid angle, below which there is quite a depression.

Only a small portion of the articular is exposed on the external side but on the internal it extends well forward. The cotylus is very convex laterally and situated well up toward the coronoid angle, while below and extending backward from it on the external side is the prominent hook-like process found in this and other genera of fishes.

Measurements:

Length of alveolar border from coronoid angle..........	52 mm.
Depth at coronoid angle..............................	10 "
Length of bone from cotyloid cavity..............	56 "
Number of teeth in 1 c m.............................	4

Lawrence, Kansas, January 5, 1899.

Some Additional Characters of the Mosasaurs.

Contribution from the Paleontological Laboratory, No. 42.

BY S. W. WILLISTON.

With Plate XII.

In the last number of this Quarterly there was a brief note concerning some interesting new features of *Platecarpus*, as derived from a remarkably perfect specimen collected the past summer in Gove county, Kansas. With the present communication is given a photographic illustration of the nuchal fringe, there briefly described. The fringe in the specimen fortunately lies slightly displaced from the vertebral column in the neck, so that it is visible as far back as the scapula of the right side, beneath which it disappears. The length of each individual "thong" cannot be made out, since they are more or less entangled, but they seem to be four or five inches long. They are numerous, starting in a close row and lying loosely on each side. I am not able to compare them with the dorsal projections of any of the recent lizards in which similar structures occur, but certainly the striking fact that such appendages do occur in this genus of the Mosasaurs, at least, adds another argument to prove the close relationship of the Mosasaurs with the lizards. The thongs were evidently nearly round in cross-section, and loose and pendulous, not standing up rigidly. The foremost ones are found in the specimen lying beneath the angle of the mandible, so that it is evident the fringe began at the posterior part of the head. How far backward it reaches can not be said without removing the bones beneath which they disappear. In all probability it continues well back along the dorsal region, possibly on the tail.

The last cervical ribs are shown in part in the illustration. The first thoracic rib, attached to the eighth post-cranial vertebra, has a length of over 300 millimeters; its distal end is covered so that its precise length can not be made out. The last cervical rib has a

length of 140 millimeters. There are twelve vertebræ that may be called thoracic. The ribs of this region measure respectively: first rib, about 350 mm.; second, 440 mm.; third, 440 mm.: eleventh, 410 mm.; twelfth, 160 mm. There are ten dorso-lumbar ribs to the beginning of the pygal region, the whole number of the precaudal vertebræ being twenty-nine. I am very much inclined to believe that the different individuals of any species may vary somewhat in the number of dorso-lumbar and post-dorsal vertebræ. The posterior thoracic ribs are more slender and less stout than the anterior ones. The costal cartilages, which are so frequently found in all the genera, are flattened and pitted, of a less dense and more granular structure than the true bones. They lie in this specimen parallel with each other in several rows.

In the present specimen there is a well ossified sternum, broadly crescentic in shape, with the posterior border concave, and the deep groves for the reception of the coracoids placed widely apart and at an obtuse angle with each other. From the fact that one of the coracoids shows much exostosial growth, united thereby with the scapula, I am inclined to believe that the ossification of the sternum may be due largely to pathological causes, and that, normally, the sternum in this genus, as in others, is composed of calcified cartilage, as are the costal ribs.

On the under side of the sternum and partially ossified with it, projecting in front as a broadly spatulate, thin process, is the interclavicle. The posterior portion is slender and not very long; at its anterior, truncate extremity, there are two oval facets, as though for articulation with bones.

The front paddle resembles in its position very much that of *P. ictericus* given by me in plate xliv, vol. iv, Univ. Geol. Surv. Kans., except that every bone is in its normal position. The edge of the fleshy portion, which is clearly outlined, follows the sweep of the radial side of the fingers about an inch distant. Between the fourth and fifth finger the edge of the membrane is concave to the tip of the fifth finger. Thence the margin extends broadly inward to the side of the body. The paddle evidently was not pedunculated, but was broadly connected with the body. The outline of the body in the abdominal region was clearly traced in collecting the specimen; it is about as it is represented in the restoration of *Clidastes*.

Not the least interesting information furnished by this specimen is that concerning the food of the animal. Quantities of its remains were discovered in the abdominal region, matted together and

more or less comminuted. A close examination of these remains discloses nothing but fish bones, and usually only those of small size. The largest observed is a vertebra of an *Empo*, or some allied fish, of about four feet in length.

These remains furnish conclusive evidence that the food of these animals consisted chiefly if not entirely of fishes, and, moreover, fishes of small or moderate size.

The skin preserved in this specimen does not differ materially from the same membrane in *Tylosaurus;* the scales appear to be somewhat larger and the carina is indistinct, though this may be due to the condition of preservation.

The hyoid bones in this genus resemble those of *Tylosaurus* (Univ. Geol. Surv., Kans., iv, pl. xxi, there wrongly referred to *Platecarpus*).

The presphenoid is well preserved in the skull; it is quite like the same element in *Varanus*.

PLATE I.

Fig. 1. *Aspidiotus forbesi* Johns. One side of anal plate of female. On cherry. Lawrence.

Fig. 2. *Aspidiotus forbesi* Johns. Anal plate of female. On crab apple. Lawrence.

Fig. 3. Variations in anal plate of the *forbesi* found on crab apple and illustrated in Fig. 2.

Fig. 4. *Aspidiotus forbesi* Johns. Anal plate of female. On apple. Lawrence.

Fig. 5. *Aspidiotus forbesi* Johns. Anal plate of female. On cherry. Seward Co., Kansas.

42-2

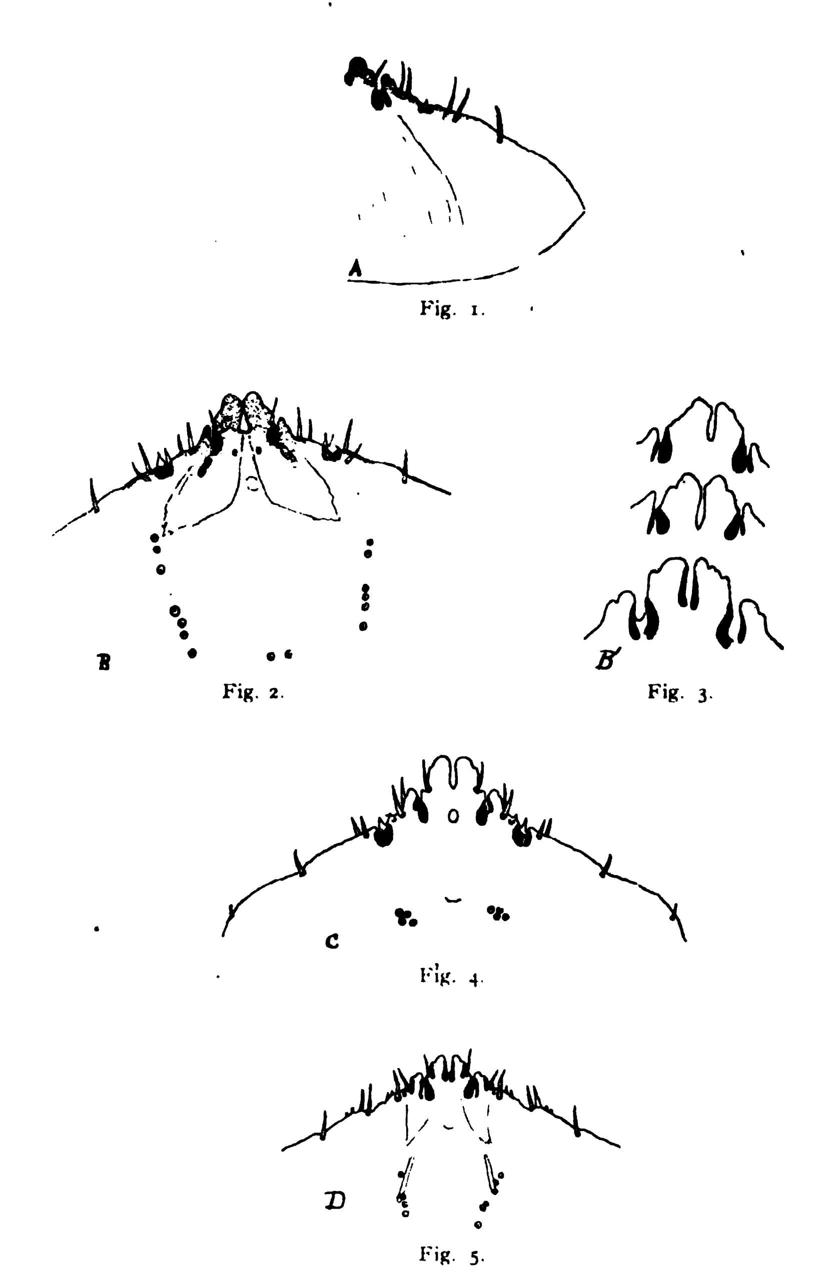


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Ella Weeks and S. J. Hunter, ad nat. del.

PLATE II.

Fig. 6. *Aspidiotus forbesi* Johns. Anal plate of female. On apple. Lawrence.

Fig. 7. *Aspidiotus forbesi* Johns. Anal plate of female. On cherry. Two miles N. W. of Lawrence.

The letters upon these Figures have no reference to letters distinguishing lots in the text upon the species. They are placed upon the Figures to call attention to the series, which are produced to illustrate variations and resemblances of *forbesi* brought together from widely separated localities and taken from different hosts.

Fig. 8. *Aspidiotus ancyclus* Putnam. Anal plate of female. On maple. Lawrence.

Fig. 9. *Aspidiotus ancyclus* Putnam. Anal plate of female. On maple. Chitinous processess deeper, more club-shaped than typical specimen. Dorsal glands smaller but more numerous than in lot from which Figure 8 was drawn.

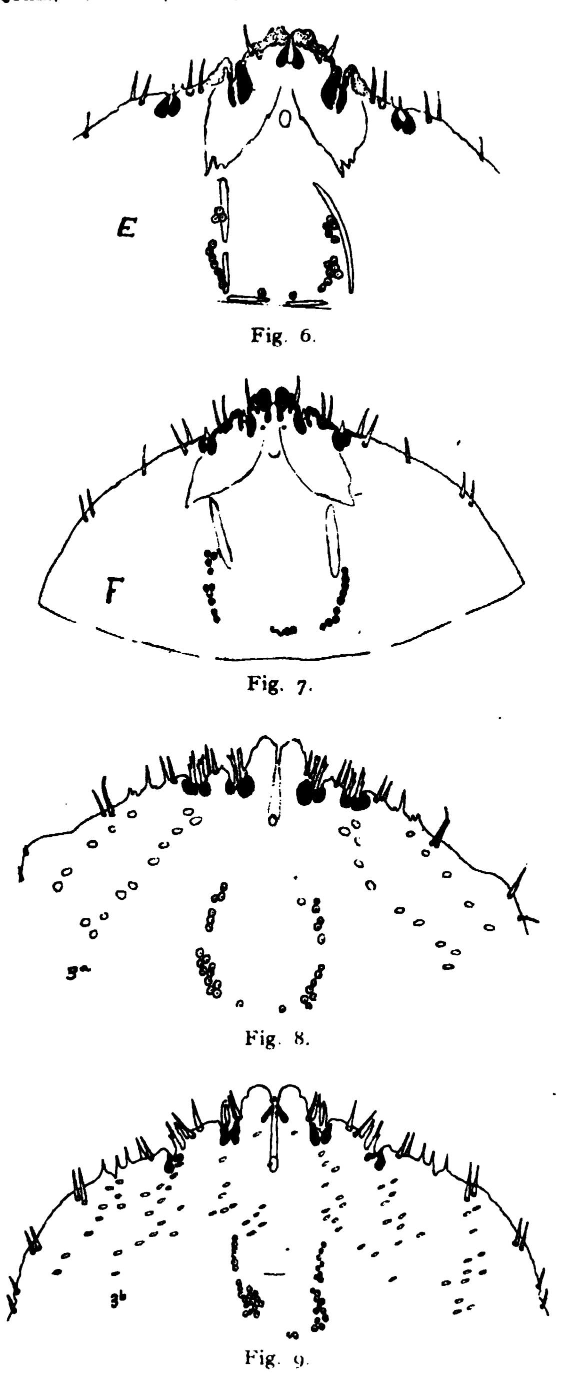


Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

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PLATE III.

Fig. 10. *Aspidiotus uvæ* Comst. Anal plate of female. On grape. Iola.

Fig. 11. *Aspidiotus uvæ* Comst. var. anal plate of female. On *Carya abla* Nutt. Lawrence.

Fig. 12. *Aspidiotus osborni* Newell and Ckll. Anal plate of female.

Fig. 13. Antenna, cephalic leg, and caudal portion of body of Nymph of *Aspidiotus osborni* Newell and Ckll.

Fig. 14. *Aspidiotus ulmi* Johns. Anal plate of female.

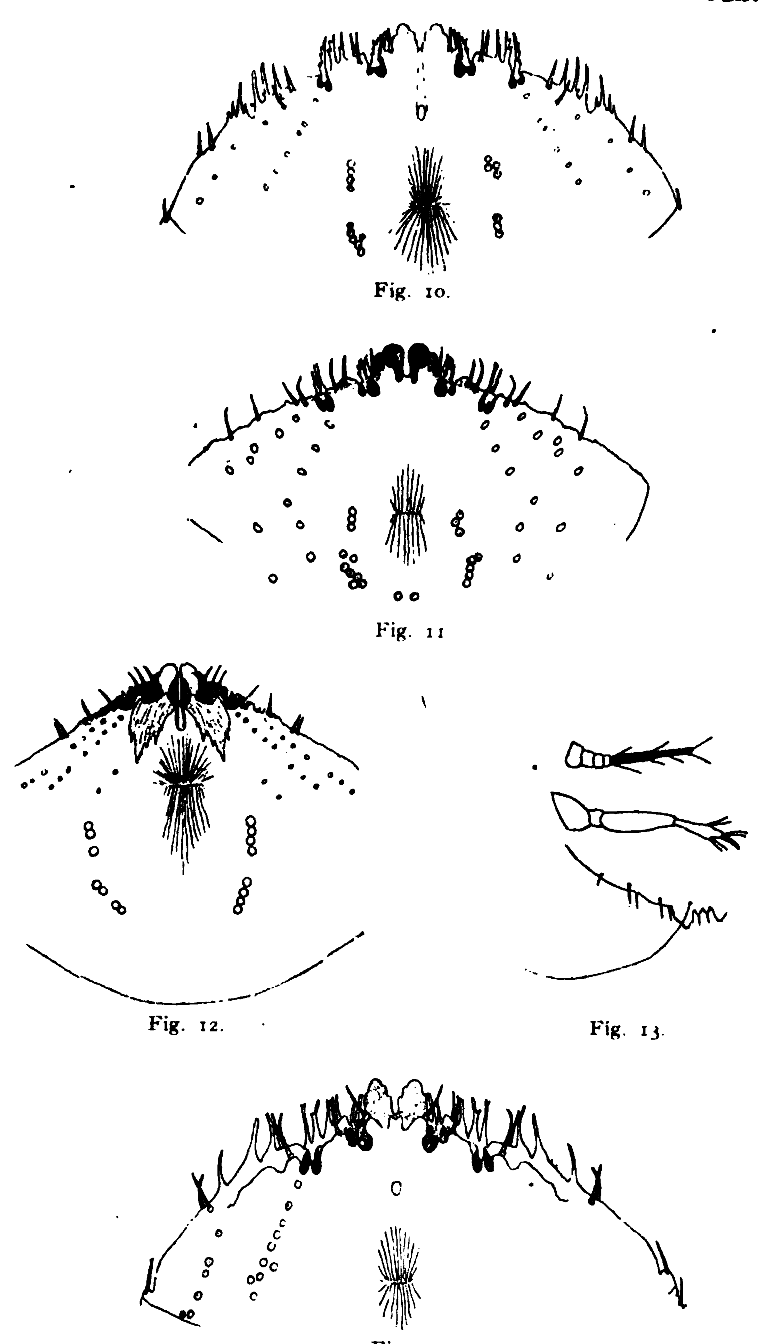


Fig. 10.

Fig. 11

Fig. 12.

Fig. 13.

Fig. 14.

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PLATE IV.

Fig. 15. *Aspidiotus fernaldi* Ckll., sub species *albiventer* sub sp. nov. Anal plate of female.

Fig. 16. Variations in anal plate of female of sub. sp. *albiventer*.

Fig. 17. *Aspidiotus juglans-regiæ* Comst. var. anal plate of female.

Fig. 18. *Aspidiotus perniciosus* Comst. San Jose scale. Anal plate of female, showing variation from original description.

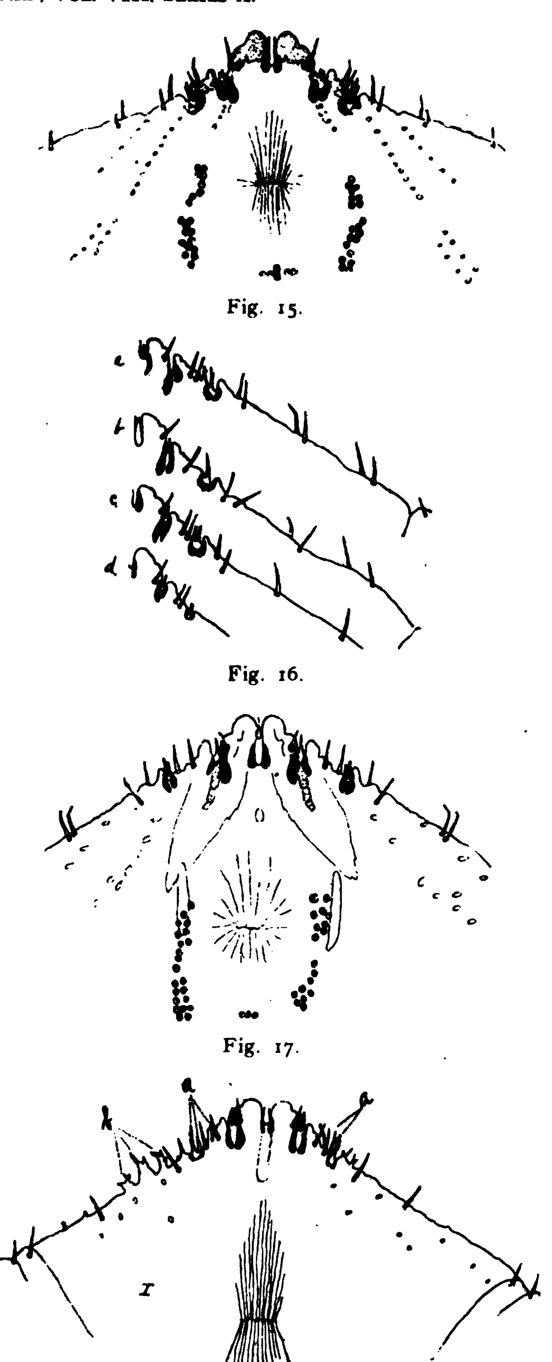


Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

Ella Weeks and S. J. Hunter, ad nat. del.

PLATE V.

Fig. 19. *Aspidiotus perniciosus* Comst. Anal plate of female showing normal structure of this lot of specimens.

Fig. 20. *Aspidiotus perniciosus.* The upper figure is the left side of anal plate and the lower figure is the right side of another specimen transposed for comparison.

Figs. 21, 22. *Aspidiotus perniciosus.* One side of anal plate of females showing variations.

Fig. 23. Newly born nymph of *A. perniciosus* Comst. Antenna and cephalic leg enlarged on the right.


PLATE V.

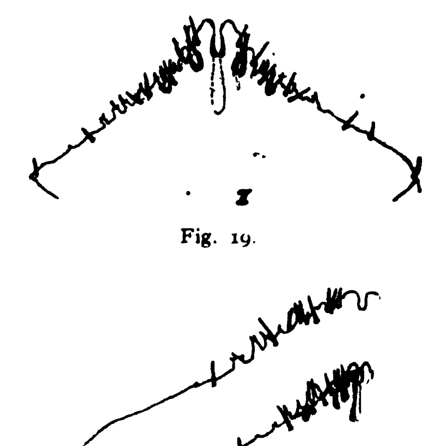


Fig. 19.

Fig. 20.

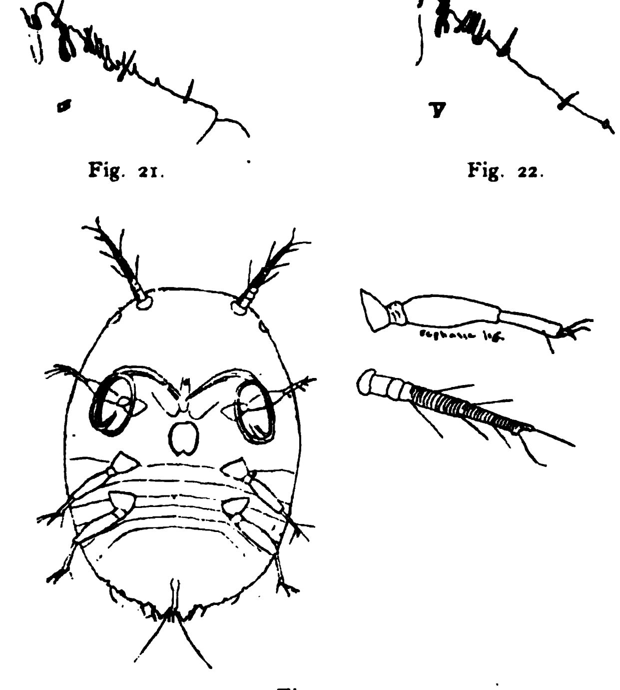


Fig. 21.

Fig. 22.

Fig. 23.

Ella Weeks and S. J. Hunter, ad nat. del.

PLATE VI.

Fig. 24. *Aspidiotus greenii* Ckll. Anal plate of female.

Fig. 25. *Aspidiotus obscurus* Comst. Anal plate of female.

Fig. 26. *Aspidiotus hederæ* Vall., var. *nerii* Bouché. Male scales showing circular shape and central position of exuviæ.

Fig. 27. *Aspidiotus hederæ* Vall., var. *nerii* Bouché. Anal plate of female.

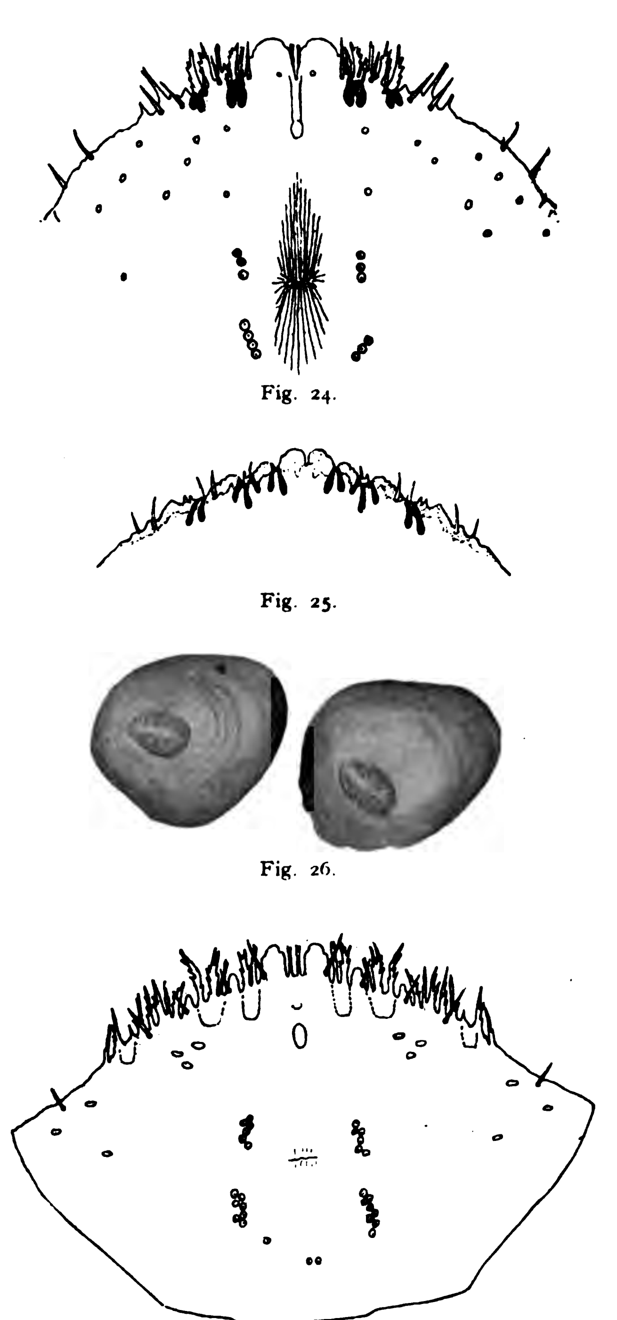


Fig. 24.

Fig. 25.

Fig. 26.

Fig. 27.

Ella Weeks and S. J. Hunter, ad nat. del.

PLATE VII.

Fig. 28. Wing, antenna, and cephalic leg of male of *A.* v. *nerii* Bouche'.

Fig. 29. Sketch showing variations in shape of the three pairs of lobes in *A.* v. *nerii* Bouche'.

Fig. 30. *Aspidiotus æsculi* Johns., sub species *solus*, sub. sp. nov. A median group of from one to two circumgenital glands was found in majority of the specimens examined. They are not shown in this figure, as they are frequently concealed beneath the club here shown. This sketch further illustrates the extreme number of plates found.

Fig. 31. *Diaspis snowii* sp. nov. Anal plate of female.

Fig. 32. *Diaspis snowii* sp. nov. Scales of males.

Fig. 33. *Diaspis snowii* sp. nov. Scales of females.


PLATE VII.

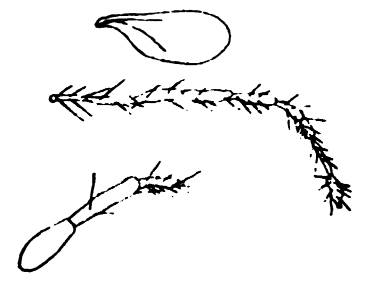


Fig. 28.



Fig. 29.

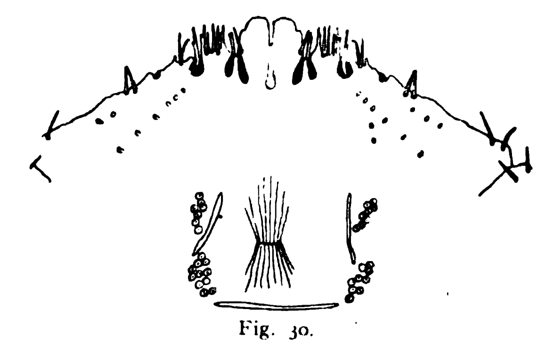


Fig. 30.

Fig. 31.



Fig. 32.





Fig. 33.

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PLATE VIII.

Posterior view of type specimen of *Bison antiquus* Leidy, Acad. Nat. Sci., Phil.



BISON ANTIQUUS LEIDY.
Type specimen.

2-17

PLATE IX.

Fig. 1, Posterior view of skull of *Bison antiquus* Leidy, **Western** Kansas.

Fig. 2, Side view of skull of *Bison occidentalis* Lucas, **Western** Kansas.

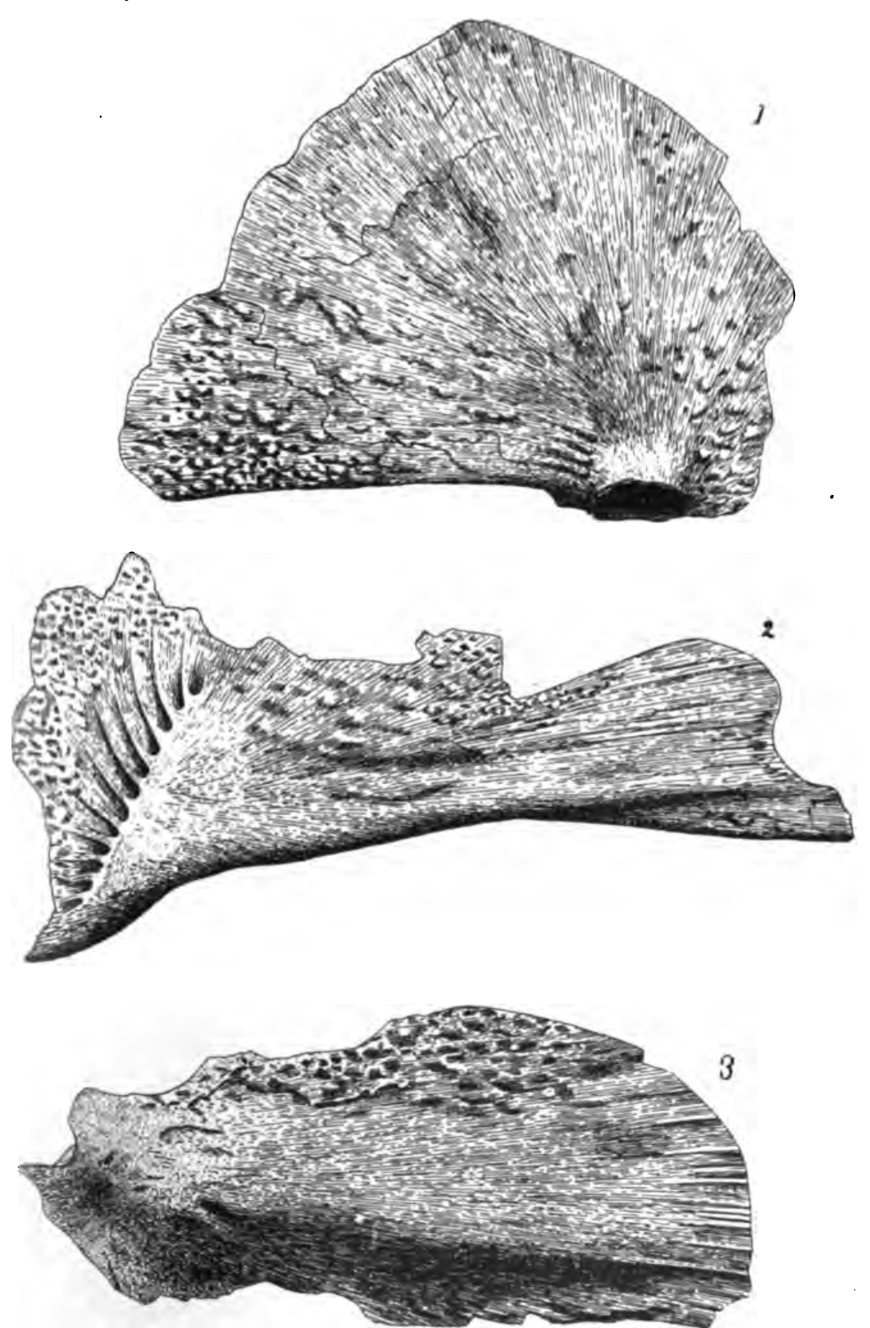


Fig. 1.
BISON ANTIQUUS LEIDY.

Fig. 2.
BISON OCCIDENTALIS LUCAS.

PLATE X.

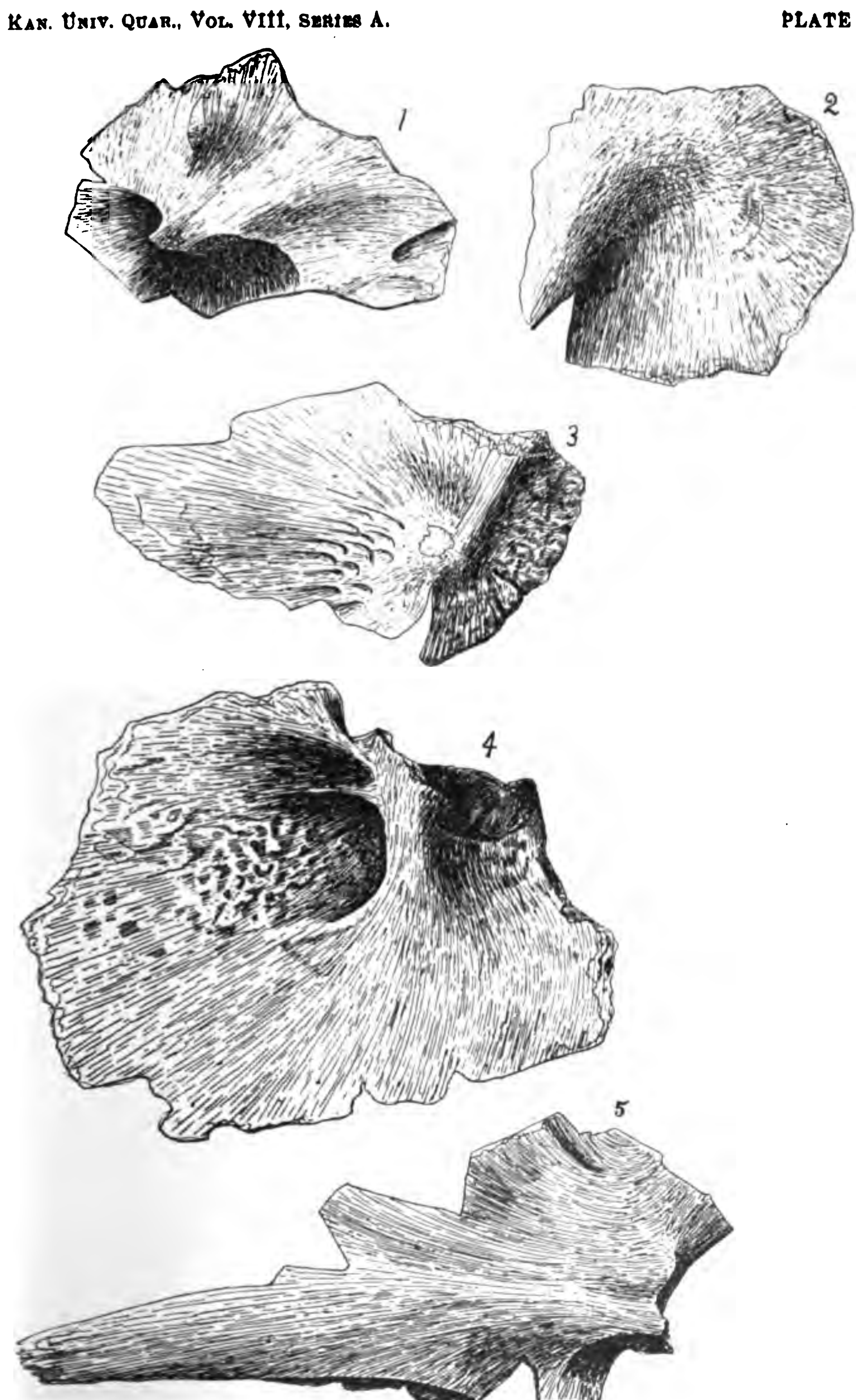
Opercular bones of *Xiphactinus*, one-third natural size:
Fig. 1, *Opercular.*
Fig. 2, *Preopercular.*
Fig. 3, Supposed *Subopercular.*



Prentice, from nature.

PLATE XI.

Figs. 1, 2, 3, 4, and 5. Bones from the region of the skull of *Xiphactinus*, the exact position of which can not be made out. One-half natural size.



S. Prentice, from nature.

PLATE XII.

Nuchal fringe and cervical ribs of *Platecarpus coryphæus*, natural size.



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KANSAS UNIVERSITY QUARTERLY.

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The Five Types of Projective Transformations of the Plane.

BY HENRY B. NEWSON.

1. It was shown in this Quarterly, Vol. IV, 1896, pp. 243-49, that there are five types of projective transformations of the points of a plane and that each of these types is characterized by its invariant figure.

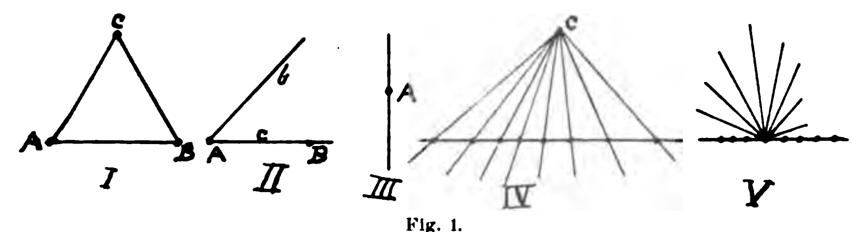


Fig. 1.

The present paper is devoted to a fuller discussion of these five types. The special or characteristic properties of each of these five types will be brought to light and the analytic expression for the transformation of each type will be reduced to a normal form.

We shall assume throughout this paper that the coefficients of the equations of the transformation are always real so that the transformations are always real. In this case the invariant figures of the different types are real in all their parts, except sometimes in type I. The invariant triangle of type I is either real in all its parts or has one real and two conjugate imaginary vertices. If the invariant triangle is real in all of its parts the transformation is said to be hyperbolic; in the second case with the invariant triangle partly imaginary the transformation is said to be elliptic.

We need a convenient and expressive notation for these five types of transformations. We shall designate a transformation of the first type by the single letter T. The hyperbolic and elliptic sub-types will be designated by $_hT$ and $_eT$ respectively. When we wish to call attention to the triangle which remains invariant we shall use the notation T(ABC). Transformations belonging to types II and III will be designated by T′ and T″ respectively. Transformations belonging to type IV and V will be designated by S and S′ respectively.

§1. Type I; Its Properties and Normal Form.

2. Three Cross-Ratios Whose Product is Unity. We shall now consider in detail the most general case (type I) whose invariant figure is a triangle. Let the vertices of the triangle be represented by A, B, C: and the opposite sides by x, y, z, respectively. Suppose in the first case that the triangle is real in all its parts, so that our transformation belongs to the hyperbolic sub-type. By means of a transformation $_hT$ the line x is transformed into itself in such a way that the points B and C on it are invariant points of the transformation. Now we know that the one-dimensional transformation of the points in a line, which leaves two points of the line invariant, is characterized by the constant cross-ratio of the invariant points and any pair of corresponding points.*

Let k_x be the characteristic cross-ratio of the one-dimensional hyperbolic transformation along the line x. In like manner we have hyperbolic transformations of one dimension along each of the invariant lines of y and z. We shall call their characteristic cross-ratios k_y and k_z respectively. In reckoning these cross-ratios the points will be taken always in the same order around the triangle. Thus we see that every projective transformation of type I in the plane determines three characteristic cross-ratios along the three invariant lines. It is also evident that the pencil of lines through the vertex A of the invariant triangle is transformed into itself in such a way that the rays AB and AC are invariant rays of the transformation. Also the cross-ratio of the invariant rays and any pair of corresponding rays of the pencil is constant for all pairs of corresponding rays; this cross-ratio is equal to k_x, the characteristic cross-ratio along the side x opposite A. Similar considerations apply to the pencil of rays through the invariant points B and C. We shall now proceed to show that these three cross-ratios are not independent, but are connected by a very simple relation.

*K. U. Quarterly, Vol. iv, 1895, p. 74.

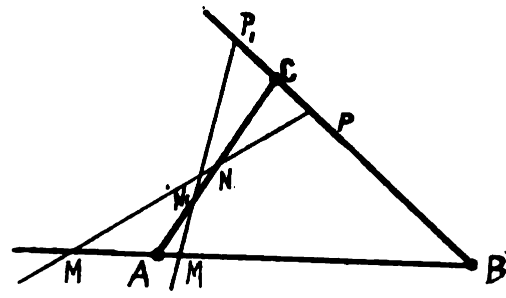


Fig. 2.

Let p and p_1 be a pair of corresponding lines in the transformation T; let PP_1, NN_1, and MM_1, be the pairs of points of intersection of p and p_1 with the sides of the invariant triangle. Since $k_z=(ABMM_1)$, $k_x=(BCPP_1)$, and $k_y=(CANN_1)$ (observe the order in which the points are taken), we have

$$k_z k_x k_y = \frac{AM.\ BM_1}{AM_1.\ BM} \cdot \frac{BP.\ CP_1}{BP_1.\ CP} \cdot \frac{CN\ AN_1}{CN_1\ AN}.$$

But by the theorem of Menelaus we have

$$\frac{AM.\ BP.\ CN}{BM.\ CP.\ AN} = 1 \text{ and } \frac{AM_1.\ BP_1.\ CN_1}{BM_1.\ CP_1.\ AN_1} = 1.$$

Hence $$k_x k_y k_z = 1. \qquad (1)$$

Theorem 1.—Every projective transformation of type I *in the plane determines a characteristic cross-ratio along each of the invariant lines and through each of the invariant points. When these three cross-ratios are reckoned in the same order around the triangle their product is unity.*

3. Elliptic Sub-type $_eT$. In the elliptic sub-type of type I the invariant triangle has one real and two conjugate imaginary vertices, Fig. 3. Along the side BC and in the pencil through the vertex A the characteristic cross-ratio is necessarily of the form $e^{i\theta}$ and this one-dimensional transformation is therefore elliptic. But along the sides AB and AC the one-dimensional transformations are not elliptic, *i. e.* the characteristic cross-ratio is not of the form $e^{i\theta}$. But the above theorem evidently holds whether the triangle is all real or whether it is part real and part conjugate imaginary; so that $k_x k_y k_z = 1$ for all transformations of type I.

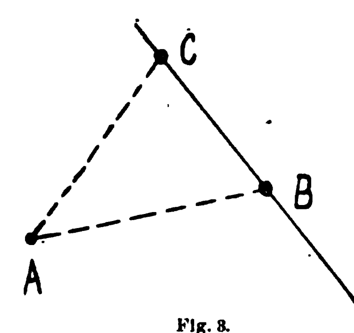


Fig. 3.

4. Cross-Ratio of Corresponding Areas. Let (ABC) be the invariant triangle, Fig. 4, of a transformation T and let P and P_1 be any pair of corresponding points in the plane, P

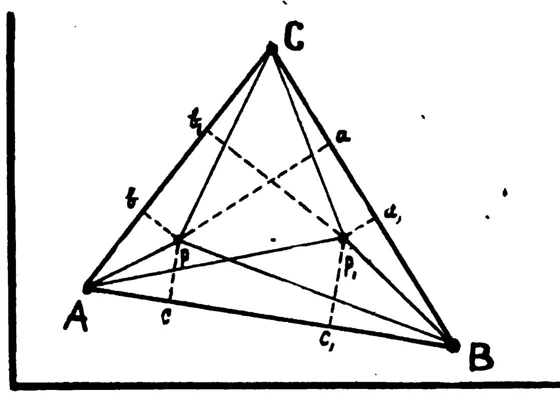


Fig. 4.

being transformed to P_1. The cross-ratio of the pencil through the vertex C is

$$k_z = C(ABPP_1) = \frac{\sin ACP}{\sin BCP} : \frac{\sin ACP_1}{\sin BCP_1} = \frac{Pb}{Pa} : \frac{P_1b_1}{P_1a_1}.$$ But the perpendiculars from P and P_1 on the sides of the triangle are proportional to the areas of the triangles of which they are the altitudes. Hence $k_z = \frac{Pb}{Pa} : \frac{P_1b_1}{P_1a_1} = \frac{\triangle PAC}{\triangle PBC} : \frac{\triangle P_1AC}{\triangle P_1BC}$.

In like manner $k_x = \frac{\triangle PAB}{\triangle PAC} : \frac{\triangle P_1AB}{\triangle P_1AC}$; and $k_y = \frac{\triangle PBC}{\triangle PAB} : \frac{\triangle P_1BC}{\triangle P_1AB}$.

We easily verify that $k_xk_yk_z = 1$. But P and P_1 were taken to be any pair of corresponding points in the plane. Remembering the theorem* that the cross-ratio of the invariant elements and any pair of corresponding elements in a one-dimensional projective transformation is constant for all pairs of corresponding elements, we have found the following important theorem:

Theorem 2.—The cross-ratio of the areas of four triangles whose vertices are any pair of corresponding points in the transformation T *and whose bases are any two sides of the invariant triangle of* T *is constant for all pairs of corresponding points.*

5. Implicit Normal Form of Equation of Type I. The equations of a projective transformation are usually given in the form

$$x_1 = \frac{ax+by+c}{a_2x+b_2y+c_2} \text{ and } y_1 = \frac{a_1x+b_1y+c_1}{a_2x+b_2y+c_2}. \quad (2)$$

When these equations represent a transformation T, they can be thrown into a normal form in which the constants in the equation are the cöordinates of the three invariant points and the characteristic cross-ratios along the invariant lines. In Fig. 4 let the

*K. U. Quarterly, Vol. iv, 1895, p. 74.

cöordinates of P be (x, y) and of P_1 be (x_1, y_1); let the cöordinates of the three invariant points be (A,B), (A_1,B_1), and (A_2,B_2).

We proved in Art. 4 the following equalities:

$$k_z = \frac{\Delta PAC}{\Delta PBC} : \frac{\Delta P_1AC}{\Delta P_1BC}; \quad k_y = \frac{\Delta PBC}{\Delta PAB} : \frac{\Delta P_1BC}{\Delta P_1AB};$$

$$k_x = \frac{\Delta PAB}{\Delta PAC} : \frac{\Delta P_1AB}{\Delta P_1AC}. \qquad (3)$$

These may be written in another form, as follows:

$$\frac{\Delta P_1BC}{\Delta P_1AC} = k_z \frac{\Delta PBC}{\Delta PAC}; \quad \frac{\Delta P_1AB}{\Delta P_1BC} = k_y \frac{\Delta PAB}{\Delta PBC}; \quad \frac{\Delta P_1AC}{\Delta P_1AB} = k_x \frac{\Delta PAC}{\Delta PAB}.$$

Expressing the areas of these triangles in determinant form in terms of the cöordinates of their vertices we have

$$\frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_2 & B_2 & 1 \end{vmatrix}} = k_z \frac{\begin{vmatrix} x & y & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}; \quad \frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}} = k_y \frac{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}};$$

$$\frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & A_1 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_2 & B_2 & 1 \end{vmatrix}} = k_x \frac{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ B_1 & B_1 & 1 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}. \qquad (4)$$

These three forms are not independent and the last may be regarded as superfluous.

Putting $\frac{1}{k_z} = k_1$ and $k_y = k_2$ then the most convenient form is as follows:

$$\frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}} = k_1 \frac{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}; \quad \frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_2 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}} = k_2 \frac{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}. \qquad (5)$$

These normal forms are capable of another interpretation; the values of the determinants are proportional to the perpendicular distances from P_1 and P to the sides of the invariant triangle. They express the fact that the cross-ratios of these perpendiculars are constant for all pairs of corresponding points.

6. Explicit Normal Forms for Type I. Equations (5) are linear in x_1 and y_1, and may be solved for these quantities, giving the explicit normal forms of the transformation T. (See Exercise 1). Solving we get

$$x_1 = \frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & A \\ A_1 & B_1 & 1 & k_1A_1 \\ A_2 & B_2 & 1 & k_2A_2 \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k_1 \\ A_2 & B_2 & 1 & k_2 \end{vmatrix}} \text{ and } y_1 = \frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & B \\ A_1 & B_1 & 1 & k_1B_1 \\ A_2 & B_2 & 1 & k_2B_2 \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k_1 \\ A_2 & B_2 & 1 & k_2 \end{vmatrix}}. \quad (6)$$

If we pass from Cartesian to homogeneous cöordinates, these forms may be written.

$$\rho x_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & A \\ A_1 & B_1 & C_1 & k_1A_1 \\ A_2 & B_2 & C_2 & k_2A_2 \end{vmatrix}; \quad \rho y_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & B \\ A_1 & B_1 & C_1 & k_1B_1 \\ A_2 & B_2 & C_2 & k_2B_2 \end{vmatrix};$$

$$\rho z_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & C \\ A_1 & B_1 & C_1 & k_1C_1 \\ A_2 & B_2 & C_2 & k_2C_2 \end{vmatrix}. \quad (7)$$

Making the C's and z's unity and dividing the 1st and 2nd by the 3rd, we get equations (6).

The law of formation of these determinants is evident. The determinant of the invariant triangle is bordered above by x, y, z, on the side by A, k_1A_1, k_2A_2, etc.

§2. Type II; Its Properties and Normal Form.

7. Two Cross-Ratios and Two Characteristic Constants. We come now to the consideration of the two-dimensional transformations of the second type, whose invariant figure is composed of two lines, their point of intersection, and a second point on one of these lines. Let T′ be a transformation of this type leaving invariant the real plane figure ABC, Fig. 5. The transformation T′ induces along the invariant

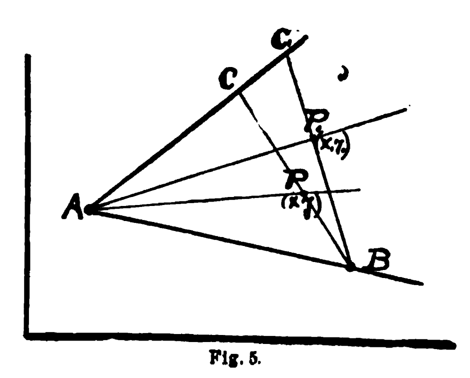


Fig. 5.

line AB a one-dimensional hyperbolic transformation whose characteristic cross-ratio is k, and in the pencil through A a one-dimensional transformation whose cross-ratio is k_1. T′ also induces along the invariant line l, and through the invariant point B parabolic transformations whose characteristic constants are respectively a^1 and a. These four one-dimensional transformations are not independent and our next problem is to determine what relations exist among them.

8. The Cross-Ratios k and k_1 are Equal. It can be shown that the two hyperbolic transformations, one along AB and the other through A, are both characterized by the same cross-ratio k when the elements are taken in the right order. The transformation T′ and its invariant figure constitute the limiting form of a transformation of the first type with invariant triangle (ABC). In the case of the invariant triangle (ABC) it was shown in Art. 2 that the product of the cross-ratios k_x k_y k_z is unity when they are reckoned in the same order around the triangle. In the triangle let C be made to coincide with A, then the ratio k_y along CA becomes unity; this gives the relation $k_x k_z=1$ or $k_x=\frac{1}{k_z}$. Now k is the cross-ratio of the pencil $A(BCPP_1)$ and $k_z=(ABXX_1)$; interchanging the rays A and B in the range we have have $\frac{1}{k_z}=(BAXX_1)$. Hence the characteristic cross-ratio of the range along AB is the same as that of the pencil through A, the order of the elements being as follows $k=(BAXX_1)=A(ACPP_1)$ where X and X_1 are a pair of corresponding points on the line AB.

9. The Two Characteristic Constants Have the Relation $a^1=\rho a$. We now go on to establish the relation between a_1 and a, the characteristic constants of the two parabolic transformations along C and through B respectively.

Let the angle lAB be ϕ and let the distance AB be d. From the theory* of one-dimensional projective transformation we have

$$a'=\frac{1}{AC_1}-\frac{1}{AC}. \tag{8}$$

and

$$a=\cot P_1BA-\cot PBA=\cot\theta_1-\cot\theta.$$

In the triangle ABC, Fig. 4, we have

$$\frac{\sin^2\theta}{\overline{AC}^2}=\frac{\sin^2\phi}{\overline{BC}^2}=\frac{\sin^2\phi}{\overline{AC}^2+\overline{AB}^2-2AC.AB\cos\phi};$$

*K. U. Quarterly, Vol. vii, 1898, p. 126.

$$\therefore \sin^2\theta = \frac{AC^2\sin^2\phi}{AC^2+AB^2-2AC.AB\cos\phi};$$

$$\therefore \frac{1-\sin^2\theta}{\sin^2\theta} = \frac{AC^2\cos^2\phi-2AC\,.\,AB\cos\phi+AB^2}{AC^2\sin^2\phi};$$

$$\therefore \cot\,\theta = \frac{AB-AC\cos\phi}{AC\sin\phi}.$$

In like manner we find,

$$\cot\,\theta_1 = \frac{AB-AC_1\cos\phi}{AC_1\sin\phi}.$$

$$\therefore\ a=\cot\theta_1-\cot\theta=\frac{AB}{AC_1\sin\phi}-\cot\phi-\frac{AB}{AC\sin\phi}+\cot\phi=$$

$$=\frac{AB}{\sin\rho}\left(\frac{1}{AC_1}-\frac{1}{AC}\right)=\frac{AB}{\sin\phi}a', \quad \text{or} \quad a'=\frac{\sin\phi}{AB}a. \quad (9)$$

Hence a' is a constant multiple of a; thus $a'=\rho a$, the constant multiplier being $\frac{\sin\phi}{AB}$.

10. Relations Unaltered by the Transformation T'. The cross-ratio of the pencil $A(BCPP_1)$ is k and it can be shown that k is also equal to the cross-ratio of the four perpendiculars from P and P_1 on the invariant lines AB and Al.

Let the feet of the perpendiculars from P and P_1 on AB be p and p_1, and the feet of the perpendiculars on Al from P and P_1 be l and l_1. Then $k=\frac{\sin PAB}{\sin PAC}:\frac{\sin P_1AB}{\sin P_1AC}=\frac{Pb}{Pl}:\frac{P_1b_1}{P_1l_1}$. In another form this becomes $\frac{P_1l_1}{P_1b_1}=k\frac{Pl}{Pb}$. This means that the cross-ratio of these four perpendiculars is constant for all pairs of corresponding points in the transformation T'.

There is another very useful relation among certain perpendiculars which can be shown to be constant for all pairs of corresponding points. Let Bl' be a line through B parallel to Al. Let the feet of the perpendiculars from P and P_1 in Bl' be h and h_1. We proceed to show that $\frac{P_1h_1}{P_1b_1}-\frac{Ph}{Pb}=m$; where m is constant for all pairs of corresponding points in the transformation T'. Denote the angles PBl' and P_1Bl' by γ and γ_1 respectively. Then $\frac{P_1h_1}{P_1b_1}=\frac{\sin\gamma_1}{\sin\theta_1}$ and $\frac{Ph}{Pb}=\frac{\sin\gamma}{\sin\theta}$ Hence $\frac{P_1h_1}{P_1b_1}-\frac{Ph}{Pb}=\frac{\sin\gamma}{\sin\theta}-\frac{\sin\gamma_1}{\sin\theta_1}$.

Since $\gamma=180^\circ-(\theta+\phi)$ and $\gamma_1=180^\circ-(\theta_1+\phi)$, we have,

$$\frac{P_1h_1}{P_1b_1}-\frac{Ph}{Pb}=\cos\phi+\cot\theta_1\sin\phi-(\cos\phi+\cot\theta\sin\phi)$$

$$=(\cot\theta_1-\cot\theta)\sin\phi=\alpha\sin\phi. \qquad (10)$$

$\therefore$ $m=\alpha\sin\phi$ and is constant for all pairs of corresponding points in the transformation T′.

11. Implicit Normal Form of the Transformation T′. The two formulas just proved enable us to write down the analytic expression for the transformation T′ in its implicit normal form. Let the coördinates of A be (A_1B), of B be (A_1B_1) and let p be the tangent of the angle which the line Al makes with the axis of x. In the formulas

$$\frac{P_1l_1}{P_1b_1}=k\frac{Pl}{Pb} \text{ and } \frac{P_1h_1}{P_1b_1}=\frac{Ph}{Pb}+\alpha\sin\phi.$$

we can substitute for these perpendiculars their analytic expression in terms of coördinates of the invariant points and the inclination p of the lines l and l′. Making these substitutions we have,

$$\frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ 1 & p & 0 \end{vmatrix} \Big/ \sqrt{1+p^2}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix} \Big/ d}=k\,\frac{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ 1 & p & 0 \end{vmatrix} \Big/ \sqrt{1+p^2}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A & B_1 & 1 \end{vmatrix} \Big/ d} \text{ and } \frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix} \Big/ \sqrt{1+p^2}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix} \Big/ d}=\frac{\begin{vmatrix} x & y & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix} \Big/ \sqrt{1+p^2}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix} \Big/ d}+\alpha\sin\phi.$$

Since $\sqrt{1+p^2}=\sec\psi$, d is distance AB, and $\alpha'=\frac{\sin\phi}{AB}\alpha$, these reduce to

$$\frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}=k\,\frac{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}; \text{ and } \frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}=\frac{\begin{vmatrix} x & y & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}+\frac{\alpha'}{\cos\psi}. \qquad (11)$$

12. Explicit Normal Form of Type II. The above equations are both linear in x_1 and y_1 as may readily be seen by expanding the determinants. Expanding and solving for x_1 and y_1 we get

$$x_1=\frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & A \\ A_1 & B_1 & 1 & kA_1 \\ 1 & p & 0 & A\alpha+1 \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k \\ 1 & p & 0 & \alpha \end{vmatrix}} \text{ and } y_1=\frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & B \\ A_1 & B_1 & 1 & kB_1 \\ 1 & p & 0 & B\alpha+p \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k \\ 1 & p & 0 & \alpha \end{vmatrix}}. \qquad \alpha=\frac{\alpha'}{\cos\psi} \qquad (12)$$

In homogeneous form this result may be written

$$\rho x_1=\begin{vmatrix} x & y & z & 0 \\ A & B & C & A \\ A_1 & B_1 & C_1 & kA_1 \\ 1 & p & 0 & A\alpha+1 \end{vmatrix}; \quad \rho y_1=\begin{vmatrix} x & y & z & 0 \\ A & B & C & B \\ A_1 & B_1 & C_1 & kB_1 \\ 1 & p & 0 & B\alpha+p \end{vmatrix};$$

$$\rho z_1=\begin{vmatrix} x & y & z & 0 \\ A & B & C & C \\ A_1 & B_1 & C_1 & kC_1 \\ 1 & p & 0 & C\alpha+0 \end{vmatrix}. \qquad (13)$$

In the final form we have the projective transformation of the second type,

$$\rho x_1=ax+by+cz, \quad \rho y_1=a_1x+b_1y+c_1z, \quad \rho z_1=a_2x+b_2y+c_2$$

expressed in terms of its essential parameters.

§3. Type III; Its Properties and Normal Form.

13. The Most Difficult Case. We come now to the consideration of projective transformations of type III. The geometric properties of transformations of this type are more difficult of determination than those of any other type and in consequence a different method is employed in the discussion of this type. A more direct method is desirable but is not at hand.

14. The Relation $\alpha'=\mu\alpha$. The invariant figure of T″ is a lineal element Al; *i. e.* an invariant point A and an invariant line l through the point A. It is evident that T″ produces a one-dimensional parabolic transformation of the points on l and also a parabolic transformation of the pencil of lines through A. We must first determine the relation of these two one-dimensional transformations.

Type III may be considered as a special case of type II in which the invariant point B is brought to coincide with A and at the same time the invariant line AB is brought to coincide with l. We proved in Art. 9 that $\alpha'=\frac{\sin\phi}{d}\alpha$, where ϕ is the angle BAl, d the distance AB, α and α' the characteristic constants of the trans-

formations through B and along l respectively. When type II degenerates to type III, $\sin\phi$ and d become zero at the same time and we have $\alpha'=\lim.\dfrac{\sin\phi}{d}\,\alpha=\mu\alpha$; μ is so far undetermined but will be shown later to have an important geometric meaning.

15. The Invariant Conic K. Let T″ be a transformation of type III leaving the invariant the lineal element Al, Fig. 6, and transforming P to P_1 and P_1 to P_2; suppose also that Q on Al is transformed to Q_1 and Q_1 to Q_2. In the invariant pencil through A we have $\cot P_1Al-\cot PAl=\cot P_2Al-\cot P_1Al=\alpha$. Along the line Al we have $\dfrac{1}{AQ_2}-\dfrac{1}{AQ_1}=\dfrac{1}{AQ_1}-\dfrac{1}{AQ}=\alpha'$ with the relation that $\alpha'=\mu\alpha$.

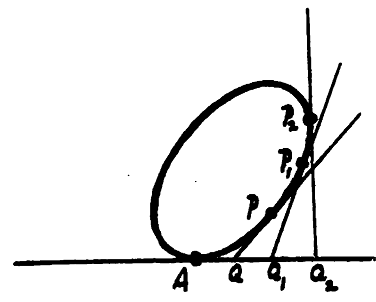


Fig. 6.

Let K be the conic touching Al at A and passing through P, P_1 and P_2. If Q be the point where the tangent to K at P cuts l, then the tangents at P_1 and P_2 will cut l at Q_1 and Q_2 respectively. Taking the origin at A and the axis of x along Al, the equation of K may be written

$$ax^2-2hxy+by^2=2y.$$

Let the cöordinates of P, P_1, and P_2 be (x', y'), (x_1, y_1) and (x_2, y_2) respectively. The tangent to K at P is given by

$$axx'-hxy'-hx'y+byy'=y+y'.$$

This line cuts Al at Q, so that

$$AQ=\frac{y'}{ax'-hy'}.$$

In like manner the intercepts on Al of the tangents at P_1 and P_2 are respectively

$$\frac{y_1}{ax_1-hy_1} \text{ and } \frac{y_2}{ax_2-hy_2}.$$

These intercepts must be AQ_1 and AQ_2 respectively; for we have, taking the difference of their reciprocals,

$$\alpha'=\frac{ax_2-hy_2}{y_2}-\frac{ax_1-hy_1}{y_1}=\frac{ax_1-hy_1}{y_1}-\frac{ax'-hy'}{y'}=$$

$$=a\left(\frac{x_2}{y_2}-\frac{x_1}{y_1}\right)=a\left(\frac{x_1}{y_1}-\frac{x'}{y'}\right)=a\alpha,$$

since $\dfrac{x_2}{y_2}=\cot P_2Al$, $\dfrac{x_1}{y_1}=\cot P_1Al$ and $\dfrac{x'}{y'}=\cot PAl$. But we know

that $\alpha' = \mu\alpha$; and if we put $\mu = a$, it follows that the transformation T″ which transforms P into P_1 and P_1 into P_2 also transforms Q into Q_1 and Q_1 into Q_2; Q, Q_1, and Q_2 being the intersections with Al of the tangents to K at P, P_1, and P_2. It follows immediately that the conic K is transformed into itself, for it is transformed into some conic K′ which must touch Al at A, since Al is an invariant element; since PQ is transformed into P_1Q_1 and P_1Q_1 into P_2Q_2, it follows that K′ must touch P_1Q_1 at P_1 and P_2Q_2 at P_2 and hence K′ is the same conic as K.

Theorem 3. The transformation T″ *which leaves invariant the lineal element* Al *and transforms* P *into* P_1 *and* P_1 *into* P_2 *also leaves invariant the conic determined by* Al, P, P_1 *and* P_2.

16. Invariant Relations. From the relation $\cot P_1Al = \cot PAl + \alpha$ we see that

$$\frac{x_1}{y_1} = \frac{x}{y} + \alpha. \tag{14}$$

where (x_1, y_1) and (x, y) are the cöordinates of P_1 and P in rectangular cöordinates. From this relation and the equation of the invariant conic through P and P_1 we can deduce another important relation between the cöordinates of P and P_1. Solving the equation $ax^2 - 2hxy + by^2 = 2y$ as a quadratic in x we have

$$ax - hy = y\sqrt{h^2 - ab + \frac{2a}{y}},$$

or

$$a\frac{x}{y} = h + \sqrt{h^2 - ab + \frac{2a}{y}}.$$

The same relation holds for x_1 and y_1, viz:

$$a\frac{x_1}{y_1} = h + \sqrt{h^2 - ab + \frac{2a}{y_1}}; \text{ subtracting we have}$$

$$a\left(\frac{x_1}{y_1} - \frac{x}{y}\right) = a\alpha = \sqrt{h^2 - ab + \frac{2a}{y_1}} - \sqrt{h^2 - ab + \frac{2a}{y}}.$$

Squaring we get

$$\frac{1}{y_1} = \frac{1}{y} + \alpha\sqrt{h^2 - ab + \frac{2a}{y}} + \frac{a}{2}\alpha^2.$$

Substituting for the radical its value, this reduces to

$$\frac{1}{y_1} = \frac{1}{y} + \alpha\left(\frac{ax - hy}{y}\right) + \frac{a}{2}\alpha^2 = \frac{1}{y} + a\alpha\frac{x}{y} + \frac{a}{2}\alpha^2 - h\alpha. \tag{15}$$

The two relations $\frac{x_1}{y_1} = \frac{x}{y} + \alpha$ and $\frac{1}{y_1} = \frac{1}{y} + a\alpha\frac{x}{y} + \frac{a}{2}\alpha^2 - h\alpha$

are independent of the character of the cöordinates whether rectangular or oblique. If oblique cöordinates are used then x_1 and y_1 are proportional to the perpendicular distances from P and P_1 on Al and Al′ some line through A.

17. Implicit Normal Form of Type III. Let the cöordinates of the points A, P, P_1 be (A,B), (x,y) (x_1,y_1) and let the line l, Fig. 7, make with the axis of x an angle whose tangent is p and let Al′ make with the axis of x an angle whose tangent is p′. Replacing the perpendiculars in the above relation by their analytic expressions in terms of the cöordinates of A, P, P_1 and l we have

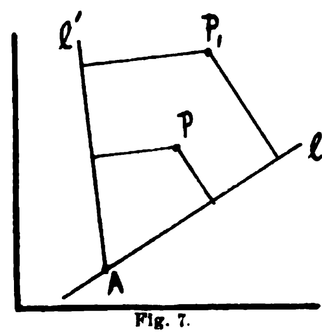


Fig. 7.

$$\frac{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}} = \frac{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}} + \alpha; \qquad (16)$$

$$\frac{\begin{vmatrix} x_1 & y_1 & 1\\ 1 & p & 0\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}} = \frac{\begin{vmatrix} x & y & 1\\ 1 & p & 0\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}} + a\alpha\frac{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}} + \frac{a}{2}\alpha^2-(h'+a)\alpha. \qquad (16a)$$

The line Al′ may be chosen so that $\begin{vmatrix} 1 & p\\ 1 & p_1\end{vmatrix} = 1$ without altering the generality of the result.

18. The Explicit Normal Form for Type III. These two equations are linear in x_1 and y_1 and their solutions for x_1 and y_1 give the explicit form for the equations of Type III. Solving we have

$$x_1 = \frac{\begin{vmatrix} x & y & 1 & 0\\ A & B & 1 & A\\ 1 & p & 0 & Aa\alpha+1\\ 1 & p_1 & 0 & A\left(\frac{a}{2}a^2-h'\alpha\right)+\alpha+1\end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0\\ A & B & 1 & 1\\ 1 & p & 0 & a\alpha\\ 1 & p_1 & 0 & \frac{a}{2}\alpha^2-h'\alpha\end{vmatrix}};$$

$$y_1 = \frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & B \\ 1 & p & 0 & Ba\alpha+p \\ 1 & p_1 & 0 & B\left(\frac{a}{2}\alpha^2 - h'\alpha\right)+p\alpha+p_1 \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ 1 & p & 0 & a\alpha \\ 1 & p_1 & 0 & \frac{a}{2}\alpha^2 - h'\alpha \end{vmatrix}} \qquad (17)$$

with the condition that $\begin{vmatrix} 1 & p \\ 1 & p_1 \end{vmatrix} = 1.$

In homogeneous coördinates these may be written

$$\rho x_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & A \\ 1 & p & 0 & Aa\alpha+1 \\ 1 & p_1 & 0 & A\left(\frac{a}{2}\alpha^2 - h'\alpha\right)+\alpha+1 \end{vmatrix};$$

$$\rho y_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & B \\ 1 & p & 0 & Ba\alpha+p \\ 1 & p_1 & 0 & B\left(\frac{a}{2}\alpha^2 - h'\alpha\right)+p\alpha+p_1 \end{vmatrix};$$

$$\rho z_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & C \\ 1 & p & 0 & Ca\alpha \\ 1 & p_1 & 0 & C\left(\frac{a}{2}\alpha^2 - h'\alpha\right) \end{vmatrix}. \qquad (18)$$

§4. Type 4: Perspective Transformation; Properties and Normal Form.

19. Single Cross-Ratio k. The fundamental invariant figure of a perspective transformation consists of a line l, a point O not on l, and the pencil of rays through O. In the special case that the point O lies on l, the transformation becomes an elation. Fixing our attention on the fundamental invariant figure we see that every invariant line in the plane except l has on it two invariant points, O and its point of intersection with l; also every pencil having its vertex A on l is an invariant pencil in the plane, and has in it two invariant rays, l and the line AO. The effect of a perspective transformation in the plane is to move a point P along the invariant line PP_1 to P_1. Thus we have on each of the invariant lines through O a one-dimensional hyperbolic transformation with two invariant points O and A. Likewise in each of the invariant

pencils with vertices on l we have a one-dimensional hyperbolic transformation. A one-dimensional hyperbolic transformation is characterized by the constant cross-ratio of the invariant elements and every pair of corresponding elements. Thus along the line AO we have $(AOPP_1)=k$. Let A_1 be a point of l; in the pencil with vertex at A_1 we have the cross-ratio $A_1(AOPP_1)=k$. Since every line through O cuts this pencil in a range having the same cross-ratio k, it follows that the one-dimensional transformations on all lines through O are characterized by the same constant k; also the one-dimensional transformations in all pencils with vertices on l are characterized by the same value of k.

Theorem 4. A perspective transformation S *of the plane is completely characterized by its fundamental figure and a characteristic cross-ratio* k.

20. Type IV a Special Case of Type I. A perspective transformation S, *i. e.* a transformation of type IV, may be regarded as a special case of type I. We proved for type I that $k_x k_y k_z=1$, where these quantities are the characteristic cross-ratios taken in the same order around the triangle. Along one side, *e. g.* BC, of the invariant triangle we have $k_x=(BCXX_1)$. If $k_x=1$ and B and C do not coincide, then X and X_1 must coincide and and every point on the line BC is an invariant point, and every line through A is an invariant line of the transformation. Thus when one of the cross-ratios as k_x of type I becomes unity without B and C coinciding, T degenerates into S, a transformation of type IV.

21. Cross-Ratio the Same on all Lines Through A. Since $k_x=1$, we have $k_z=\frac{1}{k_y}$; thus the characteristic cross-ratio along CA is the reciprocal of that along AB. Interchanging C and A in the formula for k_y we get the reciprocal of k_y; hence the cross-ratio along AC reckoned from A to C is equal to that along AB reckoned from A to B. *i. e.* $(ACYY_1)=(ABZZ_1)=k_z$. The cross-ratio of the pencil through C in $k_z=C(ABPP_1)$. But every line through A is now an invariant line and all the lines through A cut the pencil through C in the same cross-ratio k_z. Thus the transformation S produces one-dimensional transformations along each of the invariant lines through A and these one-dimensional transformations are all characterized by the same cross-ratio k.

22. Type IV a Special Case of Type II. A transformation T′ of type II is characterized by a hyperbolic one-dimensional transformation along its invariant line AB and a parabolic one-dimensional transformation along its invariant line Al. If a the characteristic constant of the parabolic transformation be equal to zero, the parabolic transformation along Al is the identical transformation and every point on Al is an invariant point. The invariant figure is now the point B, all lines through B, and all points on l.

The transformation T′ *degenerates into* S *when the characteristic constant* a *is zero.*

In T′ it was proved that the characteristic cross-ratios along AB and through A were equal. Hence it follows in the degenerate form S that the characteristic cross-ratio along any invariant line is equal to that in any invariant pencil.

23. Implicit Normal Form. The cross-ratio of the pencil $A(OlPP_1)$, Fig. 8, is k, whence we have

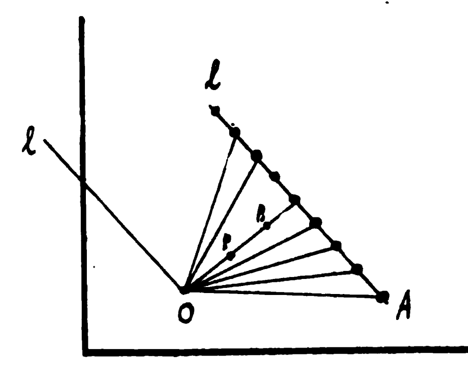


Fig. 8.

$$k = \frac{\sin PAO}{\sin PAl} : \frac{\sin P_1AO}{\sin P_1Al} = \frac{Po}{Pl} : \frac{P_1o_1}{P_1l_1}$$

where Po and P_1o are the perpendiculars from P and P_1 on the line OA, and Pl and P_1l_1 are the perpendiculars from P and P_1 on the line l. In another form this may be written

$$\frac{P_1l_1}{P_1o} = k\frac{Pl}{Po} \qquad (19)$$

In like manner the cross-ratio of the pencil $O(Al'PP_1)$, where Ol′ is parallel to Al is unity; for OP coincides with OP_1. This is given by

$$\frac{\sin POA}{\sin AOl'} : \frac{\sin P_1OA}{\sin P_1Ol'} = 1 = \frac{Po}{Pl} : \frac{P_1o}{P_1l_1} \qquad (20)$$

where Po and P_1o are the perpendiculars from P and P_1 on AO, and Pl and P_1l_1 are the perpendiculars from P and P_1 on Ol. Let the coördinates of P, P_1, O and A be respectively (x,y) (x_1y_1) (A_1,B_1) and (A,B) and let p be the tangent of the angle which the line Al makes with the axis of x. The perpendiculars in the above expression may now be replaced by their analytic expressions in terms of the coördinates giving us

$$\frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}} = k \frac{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}} \text{; and } \frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}} = \frac{\begin{vmatrix} x & y & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix}}{\begin{vmatrix} x & y & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}. \qquad (21)$$

24. The Explicit Normal Form of S. If the above equations of the transformation S are solved for x_1 and y_1, we get the following explicit normal form:

$$x_1 = \frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & A \\ A_1 & B_1 & 1 & kA_1 \\ 1 & p & 0 & k \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k \\ 1 & p & 0 & 0 \end{vmatrix}} \text{ and } y_1 = \frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & B \\ A_1 & B_1 & 1 & kB_1 \\ 1 & p & 0 & kp \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k \\ 1 & p & 0 & 0 \end{vmatrix}}. \qquad (22)$$

In homogeneous coördinates these may be written in the form

$$\rho x_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & A \\ A_1 & B_1 & C_1 & kA_1 \\ 1 & p & 0 & k \end{vmatrix}; \quad \rho y_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & B \\ A_1 & B_1 & C_1 & kB_1 \\ 1 & p & 0 & kp \end{vmatrix};$$

$$\rho z_1 = \begin{vmatrix} x & y & z & 0 \\ A & B & C & C \\ A_1 & B_1 & C_1 & kC_1 \\ 1 & p & 0 & 0 \end{vmatrix}. \qquad (23)$$

§5. Type V; Elations, Properties and Normal Form.

25. A Single Characteristic Constant a. In the case of an elation the invariant figure consists of all points on a line l and all lines through a point O on l. An elation S′ transforms a point P of the plane into P_1 some other point on the line OP. On each of the invariant lines through O there is a one-dimensional parabolic transformation having its single invariant point at O. Every pencil of lines having its vertex at A, some point on l, is an invariant pencil of the transformation. In each of these invariant pencils there is a one-dimensional parabolic transformation having l for its single invariant line.

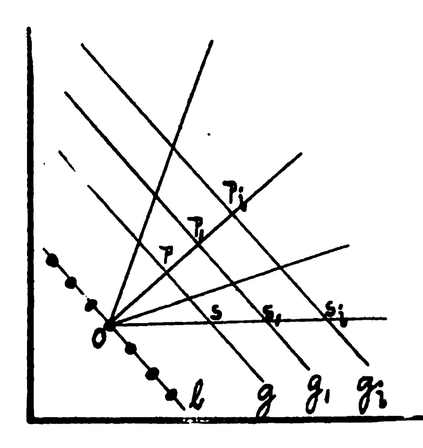


Fig. 9.

Let S′ be an elation leaving invariant the fundamental figure of Fig. 9. A line g parallel to l will be transformed into g_1 also parallel to l. For g and g_1 both belonging to a pencil whose vertex is the point at infinity on l. Some line as *i* will be transformed by S′ into the line at infinity. Let us first consider the parabolic transformation along the line OP perpendicular to l; we have

$$\frac{1}{OP_1} - \frac{1}{OP} = \frac{1}{OP_l} - \frac{1}{\infty} = \frac{1}{OP_l} = a.$$

The characteristic constant a is the reciprocal of the segment OP_l where P_l is the point that is transformed to infinity. Along any other line through O as OS making an angle θ with l we have

$$\frac{1}{OS_1} - \frac{1}{OS} = \frac{1}{OS_l} = a \sin\theta.$$

Let A any point on l be the vertex of an invariant pencil of rays and let AO=d. The elation S′ transforms AP into AP_1 and AP_1 into AK perpendicular to l. Let the angle PAO=ϕ, $P_1AO = \phi_1$, $P_lAO = \phi_l$, etc. Along OP we have

$$\frac{1}{OP_1} - \frac{1}{OP} = \frac{1}{OP_l};$$

But $\frac{1}{OP_1} = \frac{\cot\phi_1}{d}$, $\frac{1}{OP} = \frac{\cot\phi}{d}$; $\frac{1}{OP_l} = a$. Substituting these values we have

$$\cot\phi_1 - \cot\phi = da. \qquad (24)$$

Thus we have the expression for a one-dimensional parabolic transformation of the pencil of lines through a point on l.

Theorem 5. Every parabolic transformation in the plane whether along an invariant line or through an invariant point can be expressed in terms of a single characteristic constant a. *An elation is completely determined by its fundamental invariant figure and a characteristic constant* a.

26. Type V a Special Case of Type II. We showed in the last section how type IV might be considered as a special case of

type II, when $a=0$ in type II. We shall now show that type V is also a special case of type II. In type II when k, the characteristic cross-ratio of the hyperbolic transformation along AB and through A, is unity, these two one-dimensional transformations are both identical transformations and hence every ray through A is an invariant ray; therefore for $k=1$, the transformation $T'(ka)$ of type II degenerates into S' of type V.

27. Type V also a Special Case of Type III. A transformation of type V may be also regarded as a special case of type III. In type III the characteristic constants of the parabolic transformations along l and through A satisfy the relation $a'=aa$. When a is zero a' is always zero and the transformation along l is identical having all points in l invariant. But a is the radius of curvature of the invariant conic K touching l at A. The equation of the invariant conic K is

$$ax^2-2hxy+by^2=2y.$$

When $a=0$ this breaks up into two lines

$$y=0 \text{ and } by-2hx=2,$$

which are invariant lines. The line $by-2hx-2=0$ is a second invariant line through A and hence all lines through A are invariant lines. Our transformation of type III thus degenerates into one of type V.

28. Invariant Relations and Implicit Normal Form. Let P and P_1 be any two corresponding points in an elation S' and let Pl and P_1l_1 be perpendiculars let fall from P and P_1 on the line l of invariant points; let Pd and P_1d_1 be perpendiculars let fall from the same points on any other line through O as OD; evidently from the figure we have the relation

$$\frac{P_1d_1}{P_1l_1}=\frac{Pd}{Pl}. \tag{25}$$

We also have

$$\frac{1}{P_1l_1}-\frac{1}{Pl}=\frac{1}{OP_1\sin\theta}-\frac{1}{OP\sin\theta}=\frac{a\sin\theta}{\sin\theta}=a. \tag{26}$$

where θ is the angle which the line OP_1 makes with l. Let the coördinates of P, P_1, and O be (x,y) (x_1,y_1) and (A,B) respectively. Let p and p_1 be the tangents of the angles which the lines Ol and OD make with the axis of x.

We can now replace the perpendiculars in the above invariant relations by their expressions in terms of the coördinates of the invariant points and lines. Thus we get

$$\frac{\dfrac{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p_1 & 0\end{vmatrix}}{\sqrt{1+p_1^2}}}{\dfrac{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}}{\sqrt{1+p^2}}}=\frac{\dfrac{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 0 & p_1 & 1\end{vmatrix}}{\sqrt{1+p_1^2}}}{\dfrac{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}}{\sqrt{1+p^2}}};\quad \frac{\begin{vmatrix} x_1 & y_1 & 1\\ 1 & p & 0\\ 1 & p_1 & 0\end{vmatrix}}{\dfrac{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}}{\sqrt{1+p^2}}}=\frac{\begin{vmatrix} x & y & 1\\ 1 & p & 0\\ 1 & p_1 & 0\end{vmatrix}}{\dfrac{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}}{\sqrt{1+p^2}}}+a.$$

These forms reduce to

$$\frac{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}}=\frac{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}};\quad \frac{\begin{vmatrix} x_1 & y_1 & 1\\ 1 & p & 0\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}}=\frac{\begin{vmatrix} x & y & 1\\ 1 & p & 0\\ 1 & p_1 & 0\end{vmatrix}}{\begin{vmatrix} x & y & 1\\ A & B & 1\\ 1 & p & 0\end{vmatrix}}+\frac{a}{\cos\theta}. \qquad (27)$$

But p_1 is purely arbitrary and may be so chosen that $p_1-p=1$.

29. Explicit Normal Form of Type V. The above implicit normal form of a transformation S′ of type V may be solved for x_1 and y_1 giving us the explicit normal form for S′. Thus

$$x_1=\frac{\begin{vmatrix} x & y & 1 & 0\\ A & B & 1 & A\\ 1 & p & 0 & 1\\ 1 & p_1 & 0 & Aa+1\end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0\\ A & B & 1 & 1\\ 1 & p & 0 & 0\\ 1 & p_1 & 0 & a\end{vmatrix}} \text{ and } y_1=\frac{\begin{vmatrix} x & y & 1 & 0\\ A & B & 1 & B\\ 1 & p & 0 & p\\ 1 & p_1 & 0 & Ba+p_1\end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0\\ A & B & 1 & 1\\ 1 & p & 0 & 0\\ 1 & p_1 & 0 & a\end{vmatrix}};\ \begin{vmatrix} 1 & p\\ 1 & p_1\end{vmatrix}=1. \qquad (28)$$

Here a is $\frac{a}{\cos\theta}$ of the implicit normal form.

In homogeneous coördinates the last equations become

$$\rho x_1=\begin{vmatrix} x & y & z & 0\\ A & B & C & A\\ 1 & p & 0 & 1\\ 1 & p_1 & 0 & Aa+1\end{vmatrix};\quad \rho y_1=\begin{vmatrix} x & y & z & 0\\ A & B & C & B\\ 1 & p & 0 & p\\ 1 & p_1 & 0 & Ba+p_1\end{vmatrix};$$

$$\rho z_1=\begin{vmatrix} x & y & z & 0\\ A & B & C & C\\ 1 & p & 0 & 0\\ 1 & p_1 & 0 & Ca\end{vmatrix}. \qquad (29)$$

In the last form we have the projective transformation of type V expressed in terms of the essential parameters of the transformation.

EXERCISES.

1. Obtain the explicit normal form of a transformation of type I from the implicit normal form by solving equation (4) for x_1 and y_1.

Let the equations of the implicit form be written

$$\frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_2 & B_2 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}} = k\frac{N}{D}; \qquad \frac{\begin{vmatrix} x_1 & y_1 & 1 \\ A & B & 1 \\ A_1 & B_1 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}} = k_1\frac{N_1}{D}. \qquad \text{(i)}$$

Expanding and collecting:

$$x_1\{D(B-B_2)-kN(B_1-B_2)\}-y_1\{D(A-A_2)-k_1N_1(A_1-A_2)\}$$
$$=-D(AB_2-A_2B)+kN(A_1B_2-A_2B_1)$$
$$x_1\{D(B-B_1)-k_1N_1(B_1-B_2)\}-y_1\{D(A-A_1)-k_1N_1(A_1-A_2)\}$$
$$=-D(AB_1-A_1B)+k_1N_1(A_1B_2-A_2B_1).$$

$$x_1=\frac{D\begin{vmatrix} A & B & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}(AD-A_1kN+A_2k_1N_1)}{D\begin{vmatrix} A & B & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}(D-kN+k_1N_1)} = \frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & A \\ A_1 & B_1 & 1 & kA_1 \\ A_2 & B_2 & 1 & k_1A_2 \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k \\ A_2 & B_2 & 1 & k_1 \end{vmatrix}}. \qquad \text{(ii)}$$

$$y_1=\frac{D\begin{vmatrix} A & B & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}(BD-B_1kN+B_2k_1N_1)}{D\begin{vmatrix} A & B & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}(D-kN+k_1N_1)} = \frac{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & B \\ A_1 & B_1 & 1 & kB_1 \\ A_2 & B_2 & 1 & k_1B_2 \end{vmatrix}}{\begin{vmatrix} x & y & 1 & 0 \\ A & B & 1 & 1 \\ A_1 & B_1 & 1 & k \\ A_2 & B_2 & 1 & k_1 \end{vmatrix}}. \qquad \text{(iii)}$$

2. Show that the determinant of the explicit normal form of T is

$$\Delta \equiv kk_1\begin{vmatrix} A & B & 1 \\ A_1 & B_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}^3.$$

$$\Delta=\begin{vmatrix} \begin{vmatrix} B & 1 & A \\ B_1 & 1 & kA_1 \\ B_2 & 1 & k_1A_2 \end{vmatrix} & \begin{vmatrix} A & 1 & A \\ A_1 & 1 & kA_1 \\ A_2 & 1 & k_1A_2 \end{vmatrix} & \begin{vmatrix} A & B & A \\ A_1 & B_1 & kA_1 \\ A_2 & B_2 & k_1B_2 \end{vmatrix} \\ \begin{vmatrix} B & 1 & B \\ B_1 & 1 & kB_1 \\ B_2 & 1 & k_1B_2 \end{vmatrix} & \begin{vmatrix} A & 1 & B \\ A_1 & 1 & kB_1 \\ A_2 & 1 & k_1B_2 \end{vmatrix} & \begin{vmatrix} A & B & B \\ A_1 & B_1 & kB_1 \\ A_2 & B_2 & k_1B_2 \end{vmatrix} \\ \begin{vmatrix} B & 1 & 1 \\ B_1 & 1 & k \\ B_2 & 1 & k_1 \end{vmatrix} & \begin{vmatrix} A & 1 & 1 \\ A_1 & 1 & k \\ A_2 & 1 & k_1 \end{vmatrix} & \begin{vmatrix} A & B & 1 \\ A_1 & B_1 & k \\ A_2 & B_2 & k_1 \end{vmatrix} \end{vmatrix}=\begin{vmatrix} \mathbf{A} & \mathbf{B} & \mathbf{C} \\ \mathbf{A}_1 & \mathbf{B}_1 & \mathbf{C}_1 \\ \mathbf{A}_2 & \mathbf{B}_2 & \mathbf{C}_2 \end{vmatrix}.$$

Expanding **A**, **B**, etc., we have

$$\mathbf{A}=k_1A_2(B-B_1)+kA_1(B_2-B)+A(B_1-B_2),$$
$$\mathbf{A}_1=k_1B_2(B-B_1)+kB(B_2-B)+B(B_1-B_2),$$
$$\mathbf{A}_2=k_1(B-B_1)+k(B_2-B)+(B_1-B_2),$$
$$\mathbf{B}=k_1A_2(A-A_1)+kA_1(A_2-A)+A(A_1-A_2),$$
$$\mathbf{B}_1=k_1B_2(A-A_1)+kB_1(A_2-A)+B(A_1-A_2),$$
$$\mathbf{B}_2=k_1(A-A_1)+k(A_2-A)+(A_1-A_2),$$
$$\mathbf{C}=k_1A_2(AB_1-A_1B)+kA_1(A_2B-AB_2)+A(A_1B_2-A_2B_1),$$
$$\mathbf{C}_1=k_1B_2(AB_1-A_1B)+kB_1(A_2B-AB_2)+B(A_1B_2-A_2B_1),$$
$$\mathbf{C}_2=k_1(AB_1-A_1B)+k(A_2B-AB_2)+(A_1B_2-A_2B_1).$$

$$\therefore\Delta=\begin{vmatrix} k_1A_2 & kA_1 & A \\ k_1B_2 & kB_1 & B \\ k_1 & k & 1 \end{vmatrix}\times\begin{vmatrix} B-B_1 & B_2-B & B_1-B_2 \\ A-A_1 & A_2-A & A_1-A_2 \\ AB_1-A_1B & A_2B-AB_2 & A_1B_2-A_2B_1 \end{vmatrix}.$$
$$=-kk_1\begin{vmatrix} A & B & 1 \\ A_1 & A_1 & 1 \\ A_2 & B_2 & 1 \end{vmatrix}^3.$$

3. Obtain the explicit normal form of type II by solving the equations of the implicit normal form for x_1 and y_1.

4. Show that the determinant of the explicit normal form of type II is given by

$$\Delta=-k\begin{vmatrix} A & B & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix}^3.$$

5. Obtain the explicit normal form of type III by solving the equations of Art. 17 for x_1 and y_1 and show that the determinant of the explicit form is $\Delta=1$.

6. Show that T″ leaves invariant besides the conic K the pencil of conics to which K belongs, all having contact of the third order at A.

7. Obtain the explicit normal form of type IV by solving the equations of Art. 23 for x_1 and y_1 and show that the determinant of the explicit form is

$$\triangle = k^2 \begin{vmatrix} A & B & 1 \\ A_1 & B_1 & 1 \\ 1 & p & 0 \end{vmatrix}^3.$$

8. Obtain the explicit normal form of type IV from that of type I by making $k_1 = k$ and

$$\frac{B_2-B}{A_2-A} = p \text{ in type I.}$$

9. Obtain the explicit normal form of type IV from that of type II by making $a = 0$ in type II.

10. Obtain the explicit normal form of type V from the implicit form by solving equations (27) for x_1 and y_1; show that $\triangle = 1$ for type V.

11. Show that the explicit normal form of type V results when $k = 1$ in type II.

12. Show that type III degenerates into type V when $a = 0$ in the explicit form.

ADDENDA.

1. The theory of the normal forms of projective transformations in three dimensional space is wholly analogous to the theory of those in the plane set forth in this paper. The explicit normal forms for the thirteen types in space have been determined and most of the forms generalized for n dimensions. These results will be published later.

2. In one-dimension there are but two types of the transformation, $x_1 = \frac{ax+b}{cx+d}$, these are the well known forms:

$$\frac{x_1-A_1}{x_1-A} = k\frac{x-A_1}{x-A}, \qquad \frac{1}{x_1-A} = \frac{1}{x-A} + a.$$

These explicit forms when solved for x_1 give respectively

$$x_1 = \frac{\begin{vmatrix} x & 1 & 0 \\ A & 1 & A \\ A_1 & 1 & kA_1 \end{vmatrix}}{\begin{vmatrix} x & 1 & 0 \\ A & 1 & 1 \\ A_1 & 1 & k \end{vmatrix}}; \qquad x_1 = \frac{\begin{vmatrix} x & 1 & 0 \\ A & 1 & A \\ 1 & 0 & Aa+1 \end{vmatrix}}{\begin{vmatrix} x & 1 & 0 \\ A & 1 & 1 \\ 1 & 0 & a \end{vmatrix}}.$$

The analogy of these forms with the forms for the plane is evident.

The determinants of these forms are respectively

$$\triangle = k \begin{vmatrix} A & 1 \\ A_1 & 1 \end{vmatrix}^2 \text{ and } \triangle = 1.$$

3. The most general form of projective transformation in space leaves invariant a tetrahedron. The explicit normal form in homogeneous coördinates is as follows:

$$\rho x_1 = \begin{vmatrix} x & y & z & w & o \\ A & B & C & D & A \\ A_1 & B_1 & C_1 & D_1 & kA_1 \\ A_2 & B_2 & C_2 & D_2 & k_1A_2 \\ A_3 & B_3 & C_3 & D_3 & k_2A_3 \end{vmatrix}; \quad \rho y_1 = \begin{vmatrix} x & y & z & w & o \\ A & B & C & D & B \\ A_1 & B_1 & C_1 & D_1 & kB_1 \\ A_2 & B_2 & C_2 & D_2 & k_1B_2 \\ A_3 & B_3 & C_3 & D_3 & k_2B_3 \end{vmatrix}:$$

$$\rho z_1 = \begin{vmatrix} x & y & z & w & o \\ A & B & C & D & C \\ A_1 & B_1 & C_1 & D_1 & kC_1 \\ A_2 & B_2 & C_2 & D_2 & k_1C_2 \\ A_3 & B_3 & C_3 & D_3 & k_2C_3 \end{vmatrix}: \quad \rho w_1 = \begin{vmatrix} x & y & z & w & o \\ A & B & C & D & D \\ A_1 & B_1 & C_1 & D_1 & kD_1 \\ A_2 & B_2 & C_2 & D_2 & k_1D_2 \\ A_3 & B_3 & C_3 & D_3 & k_2D_3 \end{vmatrix}.$$

The determinant of this form in Cartesian coördinates is as follows:

$$\triangle = kk_1k_2 \begin{vmatrix} A & B & C & 1 \\ A_1 & B_1 & C_1 & 1 \\ A_2 & B_2 & C_2 & 1 \\ A_3 & B_3 & C_3 & 1 \end{vmatrix}^4.$$

4. The normal forms of projective transformations in this paper though deduced from geometric considerations for real transformations hold also for complex variables.

The Coccidæ of Kansas, II.

Contribution from the Entomological Laboratory, No. 66.

BY S. J. HUNTER.

With Plates XIII to XVII.

In the study of the material here presented, it was found that the most satisfactory mounts were made from specimens boiled in a solution of KOH composed of equal parts of water and saturated solution of the potassium hydrate. The material was allowed to boil several minutes, then was transferred to warm water and washed with camel's hair brush until all the coloring matter had left the body. From here the specimens were readily transferred to glycerine jelly for temporary study or through the clearing mixture mentioned in the previous paper into balsam for permanent reference.

I am again placed under obligations to Professor T. D. A. Cockerell who has very kindly read the manuscript and given some notes upon the species here studied. The drawings accompanying this paper were made by Miss Ella Weeks under the author's immediate supervision. Thanks are due her for the care and skill exercised in their production.

All measurements given, both in text and plates, are in micro-millimeters.

Lecanium macluræ nov. sp. Plate XIII, Figs. 1, 2.

Female. Scale; long. 3 to 5, lat. 2½ to 4, alt. 1½ to 2, μ. Color light brown, older scales comparatively flat, younger scales when dry wrinkle up forming ridges on longitudinal median line. In older specimens the longitudinal median surface is smooth, this area being fusiform, but not greatly enlarged in the center. Fusiform space pitted on each side, the lateral surface in folds; the depressions each contain several small pits. The caudal margin somewhat plicate. The edges of body wall not upturned on median margins of caudal opening. Gland pits in derm compara-

tively few. Mouth parts prominent, and bearing a well developed triangular labium having three prominent spines on lateral margins.

Antennæ seven jointed, the fourth being the largest, the sixth the shortest. Beginning with the proximal segment they measure 56-68; 32-36; 56-68; 52-56 28-40; 20-24; 28-32; micromillimeters respectively. Chætotaxy and structure shown in figure. In some specimens sutures between 1 and 2, in others sutures between 3 and 4, 5 and 6 are indistinct. The third and fourth are without spines, the remaining segments show spines as indicated in figure.

The legs are well developed, and highly chitinized. The body when boiled in KOH gives reddish brown coloring matter and becomes clear, the legs however retain part of their chitine. Trochanter prominent, prothoracic leg in some specimens shows unusually long hairs, two on trochanter, one on coxa; hairs elsewhere as indicated in figure. Claw curved, with two stout knobbed digitules. The second digitule of claw seen only in the mesothoracic leg. Tarsus bearing two long slender knobbed digitules. Chætotaxy and relative sizes of segments shown in figure.

Habitat. On the twigs of osage orange, May 18, 1898. These specimens were received from Claflin, Barber county, through the Honorable F. D. Coburn Secretary of the State Board of Agriculture. The twigs were thickly covered with scales but so thoroughly were they parasitized by chalcids and attacked by the larvæ of a coccinellid that it was with difficulty that suitable material for study was obtained from material sent. These insects are widely separated from *L. maclurarum* Ckll. Description of *L. robiniarum* Douglas is not at hand. I note however that a probable variety has been found in New Mexico* on osage orange. The parasites left no eggs for comparison, so even this remote clue is wanting. Professor Cockerell says: "It isn't *robiniarum*. It is related, I think, to *L. fitchii*."

Lecanium canadense Ckll. Plate XIV, Figs. 1, 2, 3.

Lecanium caryae v. canadense Ckll. Can. Ent., Vol 27, 1895, p. 253.

Lecanium canadense Ckll. Can. Ent., Vol. 30, p. 294.

This scale at first glance resembles scale of *L. kansasense* but upon close examination the smooth central boss is not so apparent, nor raised smooth ridge on each side of the boss. The legs and antennæ present still greater distinctions. Scale of female, long. 4 to 5½; lat. 4; alt. 3½ to 4 μ. Hemispheroidal, and caudal margin slightly extended. Some specimens show slight elevation on center of dorsum, others not raised but shiny on dorsum and with but

*Ckll. Can. Ent. '95, p 257. Insect Life. Vol. VII, p. 209.

few pits. Caudal half of lateral portion of body plicate. Color very dark brown, pits nowhere deep, unpitted surface shiny. Derm, when bleached shows numerous gland pores.

Antennæ six jointed. Professor Cockerell adds: "This species occasionally shows 7 jointed antennæ." The third joint about 1/3 length of whole member, the sixth shows distinct compression which suggests a suture but none could be found in specimens examined. Individual lengths and comparative sizes of segments shown in figure.

Leg, size of segments variable. Trochanter prominent. Limits of forms of this species studied:

C. 120–140; tr. 68; fem. 180–204 (including tr); tib. 120–152; tars. 80–88: cl. 12–12.

Only one long slender tarsal digitule seen, knobbed: two short stout digitules belong to the claw.

Habitat on *Ulmus americana* University Campus, April, 1898 Collected by Mr. P. A. Glenn.

Lecanium kansasense, nov. sp. Plate XIV, Figs. 4, 5.

Female, long. 3 to 5½, lat. 2½ to 3½, alt. remains constant at 2, μ. Color dark brown, very shiny, derm apparently thick, when boiled in KOH becomes translucent retaining some coloring. Derm checkered with numerous gland pits. Some scales, when taken, March, '98, were sparsely covered with white powder. When scale is removed distinct oval ring with anal indentation distinctly apparent upon bark of host.

On median surface of dorsum is a smooth space, oval-shaped and slightly raised, bordered on each side by row of punctures. Some specimens show slight smooth elevation and another row of punctures laterad of first rows, so that boss from long focus appears to be encircled by two rows of pits. Lateral and caudal aspects plicate, cephalic aspect minutely wrinkled.

Antennæ six jointed, structure, average length, and arrangement of hairs shown in figure. Third joint a little longer than 4+5+6. Segments always well marked. Terminal hair equal in length to proximal joint.

Leg strongly chitinized, does not bleach as readily as derm. Number and position of digitules, average length of segments and chætotaxy shown in figure.

Habitat. On *Cersis canadensis L.*, University Campus, January, 1898.

I am inclined to associate with this species scales of *Lecanium*,

insufficient in number for thorough study, taken from *Juglans nigra*, a potted rose, and from *Ulmus fulva*. In none of these were either legs or antennæ found. The paucity of material, therefore, prevents a more positive opinion. From the scales, however, it is evident that they are closely related, if not identical. Of the scale on *Ulmus fulva* Professor Cockerell says: "I feel confident that the one on *Ulmus fulva* belongs here." If these can subsequently be proven identical, it will be of interest in showing the range of adaptability of this species.

Lecanium cockerelli nov. sp. Plate XV, Figs. 1, 2, 3.

Scale of female. Average long. 8.5, lat. 5 to 6 (apparently governed by width of branch), alt. 3, μ. Scales of extreme length are long. 10.4, lat. 6.6, alt. 4.2 This striking scale will be easily recognized by its two prominent tubercles on the cephalic half of the body, situated laterad of the longitudinal median line. From these tubercles the body descends rapidly cephalo-ventrad to the bark of host, giving the cephalic aspect somewhat of the appearance of the upper part of the face of a bull dog. From the tubercles the body slopes gradually caudo-ventrad to the bark of the host. Derm closely pitted with shallow punctures, color very dark brown.

When removed from bark the margin of the insect leaves an elliptical ring, central portion of which is covered by a white powder. By transmitted light derm is shown to be closely perforated by minute gland pores.

Antennæ, stout, eight segments, arrangement of hairs and length of segment shown in figure. Leg stout, tarsus bears two long slender knobbed digitules, claw with two stouter digitules, length of claw and tarsus 128 micromillimeters.

Habitat. Taken February, 1898, on *Ulmus americana* in Lawrence, Kansas. Many of the outer branches of trees were closely studded upon the upper surface by these scales. The same trees were examined February of this year and but a single specimen was found. I cannot charge this disappearance to parasites exclusively. I would rather believe that the severe weather and the two very heavy sleets that covered the trees and remained upon them for several days were largely responsible for the clearance of old scales.

This attractive species is dedicated to Professor T. D. A. Cockerell whose studies have greatly enriched Coccidological literature.

On walnut, the same species was found, but the scale is uniformly smaller and the size of segments of leg and antennæ correspondingly less. Long. 6–7, lat. 4–5, alt. 3–4, μ. A comparison of figure 2 with figure 3 will show differences in size of the antennæ and legs of the walnut and elm scales.

Habitat on *Juglans nigra*, University Campus, April, '98.

From the relative sizes can it be said that elm is the better adapted host?

Professor Cockerell writes that he has received specimens of this scale from Mr. G. B. King and several other correspondents but the material was in unfit condition for description,

Lecanium armeniacum Craw. Plate XV, Fig. 4.

Comparison of the infested twigs with photograph upon title page of bulletin No. 83 Cornell University by M. V. Slingerland, suggests a possibility of this being the same species. Later, however, in the description, Professor Cockerell is quoted as associating that insect with *juglandis*, a 7-jointed species. There being no descriptions, specimens *in situ*, or slide specimens at hand the following notes are offered.

Scale of female, crowded closely upon twigs of plum sometimes 2 and 3, one upon another. Color of scale pale brown; some of scales full and show no foldings, others show a row of pits on each side of longitudinal median line and sides plicate. Some scales have retained their form while others are much shriveled up. The shape of scales, hemispheroidal with sides somewhat depressed. Long. 4, lat. 3, alt. 2.5, μ.

Antennæ 6 and 7 jointed, the basal joint quite stout and globular, the first and second segments bear unusually long hairs, the third segment (when 7 jointed) bears one, the fourth again bears two unusually long hairs. Further chætotaxy and relative dimensions shown in figures.

Legs are slender and might be characterized by the marked constriction at the joints. There is an exception to this, however, in the case of the trochanter and femur. Here the segments are simply marked off by a straight line, no noticeable indentation being apparent on the margins. Tarsus bears two long slender knobbed digitules, claw bears two much shorter and stouter digtules.

Habitat, on plum twigs. This insect was found by the writer among the collections and bore the label "Scale bugs on plum, Kansas." Reference to the lot number showed that these scales

were taken by Prof. V. L. Kellogg in 1891. The date of collection was not given but upon twigs there remained some leaves and blossoms so that the time of the year can be satisfactorily determined.

A comparison with descriptions of *L. rugosum* Sig.* shows not "rugose" but plicate, not "hills" but ridges and furrows upon the sides. The plum scales are light brown. Antennæ 6 and 7 jointed, never "eight"; in view of obscurity of segmentation, it is interesting to note that the plum scale agrees with *rugosum* in that 3 exceeds part distad of 3, if 3+4 are one segment as in plate, figure 4 *a*, but if they are as drawn in same plate, figure 4 *b*, joint 3 is less than all distad. Size uniformly smaller than *rugosum*, plum scale elongate, *rugosum* circular. Groove in anterior tarsus not shown: posterior tarsus not wider than tibia; chætotaxy not similar.

With the Queenston scale:†—"legs well developed," trochanter has "one" hair, coxa bears not "one" but two long and two short hairs. Length of femur, tibia and tarsus within possible bounds, but digitules of claw not "long" but short and stout extending but little beyond claw.

No further literature being at hand for comparative study I sent this scale with my notes to Professor Cockerell. He says. "This scale has much in common with *L. armeniacum*, yet seems not quite the same. I wish we knew the sub- adult (living) female and the newly hatched larva." Professor Cockerell kindly sent me specimens of *armeniacum*. A comparison shows, legs similar; antennæ agree with seven segmented specimens except that 5th joint in *armeniacum* is shorter than in plum insect.

The greatest difference appears to be in the scale itself. When bleaching, it colors the fluid a yellowish ochre; the plum scale gives off brownish coloring. Scale of *armeniacum* is not plicate and shows no longitudinal median raised smooth ridge: this insect, *armeniacum*, is more hemispheroidal with side quite full; plum scale more elongate and flattened.

Professor Cockerell suggested that Mr. Theo. Pergande be consulted since he has been working upon these fruit tree Lecaniums.

Accordingly I have received the following from Mr. Pergande through Dr. Howard:

"I have examined and compared the specimens sent with mounted and dry material of *Lecanium armeniacum* in our collection, and have come to the conclusion that the plum scale from Kansas

*Translated by Mrs. T. D. A. Cockerell, Can. Ent. Vol. 27, p. 59.
†T. D. A. Cockerell, Ibid, p. 69.

is identical with the above species. With regard to the difference in length of one or the other of the antennal joints, as noticed, I will say that it is simply individual variation; even in the same specimen the comparative length of either of the joints of both antennæ varies frequently more or less. There is generally also a more or less perceptible variation in size, color and shape in the same species, dependent, in a measure, on the food plant on which it may have established itself, and also on the locality. Old specimens, which have attained their full growth and have died a natural death, are generally darker, if prepared for the microscope, than younger individuals of the same stage and with all the pores of the germ much more distinct. As to the shape of the individual scales and their sculpturing, I find in our material of typical specimens of *Lecanium armeniacum* the same variations as those mentioned."

The limitation of variations within a species never fails to be of interest. With a view to setting these forth in this species the following data are given concerning the antennæ:

After examining the antennæ of 19 bleached insects from plum by means of a $\frac{1}{12}$ oil immersion objective, it was found that four of this number bore 7 jointed antennæ, two showed faint trace of suture between 3 and 4 (of the 7 jointed variety) and thirteen bore distinctly 6 segmented antennæ, 3 and 4 appearing as one and about equal in length to 3 + 4 of the 7 segmented antennæ. Measurements of antennæ of representative insects will show these variations in detail.

A brace is used to show that the two antennæ belong to the same insect. In this connection it is well to note the variations in number of segments within the individual as shown in the cases of *f* and *i*.

Lot No. of Specimen.	1st	2d	3d	4th	5th	6th	7th
a	44	44	56	48	20	20	40
b	44	40	48	52	20	20	40
c	48	44	100		24	28	32
d	48	40	100		24	24	40
e	48	44	92		16	24	44
	36	48	100		20	24	40
f	48	36	108		20	24	44
	52	40	56	56	24	24	40
g	48	44	96		20	24	46
	44	32	108		24	20	44
h	48	28	92		20	20	40
i	44	40	96		20	24	40
	48	40	52	44	24	20	40
j	46	40	92		24	20	44
	44	44	92		24	20	40
k	44	40	88		24	20	40
	48	44	100		24	20	48
l	44	40	52	44	..	..	..

Antennæ of *L. armeniacum** on prune, from Healdsburg, California (Ehrhorn).

m	48	40	56	48	20	16	40
	36	40	48	46	16	20	40
n	48	40	56	52	20	24	40
	36	40	52	56	20	24	·40

Lecanium hesperidum L. Plate XVI, Figs. 1, 2, 3.

Habitat. In conservatories on *Abutilon* sp. and *Citrus* sp. In green house on *Citrus* sp., *Hedera helix* and *Nerium oleander.*

This species was found on trunk, branches, leaves and fruit of the citrus trees. The scales upon the trunk are darker and more convex than those on branches. Those on branches and leaves incline to be yellowish, while those on the trunk are grayish. The outlines of both remain the same (Plate XVI, Fig 1) except when modified by mid rib or by bordering on branch.

The scales on ivy and oleander are uniformly darker than orange scales; some of them are amber colored. The marginal outline is ovate, cephalic half being the wider. These scales are also more convex than the orange scales, and show on dorsum in some cases the figure H, the transverse bars joining the marginal spikes.

Antennæ, legs and nymphs of all these scales agree in structure.

The subject of tesselation naturally arises in this connection. Considerable attention has been paid to the bleached derm. The results obtained, however, have not been constant. With the aid of favorable reagents and suitable stains it is hoped that some definite data may be secured which will admit of something being said upon this point at a later date.

Lecanium coffeæ Walker. Plate XVI, Fig. 4.

Habitat. On sword fern, *Pteris* sp., green house, Lawrence.

Lecanium oleæ Bernard. Plate XVI, Fig. 5.

These scales differ in number and relative sizes of segments of antennæ as compared with Comstock's description in U. S. Ag. Rep., 1880, p. 336.

*Since the above went to press I have received the following concerning *L. armeniacum* on prune from Mountain View, California (Ehrhorn): "Antennæ (1) 47, (2) 28, (3) 45, (4) 59-62, (5) 18-19, (6) 20, (7) 45. One antenna appeared to have only six segments, 6 measuring 42 micro-millimeters. The legs were not obtained in good condition but the coxa is 90, the femur with trochanter 145 micro-millimeters." Cockerell and Parrott, Industrialist. April. 1899, p. 233.

An examination of five of the Healdsburg prune *armeniacum* gave cephalic leg—coxa 88, tr. 52, fem. 104, tib. 100, tar. and cl 76: meta-thoracic leg—coxa 96-104, tr. 56, fem. 128, tib. 120, tar. and cl 84.

Habitat. on *Nerium oleander*, green house, Lawrence.

Professor Cockerell notes upon this species: "The typical antenna has 8 segments. These examples vary in the direction of *L. mirandum*, Ckll. and Parrott, ined., from Tlacotalpan, Mexico, and a study of them, together with other material, has led me to be of the opinion that *mirandum* is, after all, only one of the forms of *oleæ*."

Lecaniodiaspis (?) parrotti nov. sp. Plate XVII, Figs. 4, 5.

Turtle shaped back resembles somewhat the carapace of *Chelydra serpentina*. 7 tubercles compose median carina, the second the longest, then graduated dorsad, radiators extend down and out from tubercles. Ribs on dorsum apparent, corresponding in number, position and size to the median tubercles. Ribs bear distinct elevations midway between carina and margin of body, and where ribs meet margin are to be seen protuberances corresponding in size to the median tubercles.

Marginal outline forms an oval; cephalic margin bears three small tubercles, the median pointed, the ones on each side obtuse, the three being nearly equal in size. At the caudal extremity of longitudinal median carina is a prominent quadrangular structure, extending caudad from margin of the body.

Thickness of body 1.1 μ., margin of dorsum elevated from bark .4 μ. Dorsum and side wine colored, covered in places by grayish white, derm of body wrinkled, waxy secretion apparent under ventrum.

Described from one specimen *in situ* on *Aesculus glabra*, and named in honor of Mr. P. J. Parrott of the State Agricultural College. Taken 4 miles west of Lawrence, February 9, 1899.

This specimen was opened and within there was found the pupa of a parasitic hymenoptera, which in its development had destroyed the larger part of the body of the insect, so that it could not be ascertained whether the antennæ were present, rudimentary or absent. It is therefore placed provisionally in *Lecaniodiaspis*. The segmentation and chitinization of ventrum of that part of the body examined resembled the same portion of the body of *pruinosus*. The scale itself is quite characteristic and will, I believe, be readily recognized from the two figures accompanying this description. In this connection it is fitting to record that Professor Cockerell wishes to say that in his opinion *Lecaniodiaspis artemesiæ* Ckll should be transferred to *Solenococcus* as *Solenococcus artemesiæ* Ckll.

Lecaniodiaspis celtidis Ckll., sub. sp. **pruinosus** sub. sp nov. Plate XVII, Figs. 1, 2.

Female: long. 4, lat. 3, alt. 1, μ. Median carina and interrupted transverse ridges distinctly seen in younger specimens, less apparent on dorsum of old scales. Scales slightly convex, sides of dorsum arise from bark of host. Color pale ochrous with frosty white covering. The color and shape resemble *celtidis* but in *celtidis* the frosting is coarser and *celtidis* does not show median carina or segmentation on dorsum.

Anal margins bearing hairs, two bristles prominent on tips of each anal plate. Antennæ eight jointed, joints distinct, measurements and chætotaxy shown in figure.

Ventrum distinctly segmented showing chitinized plates transverse and longitudinal. Mouth parts prominent, setæ 1.48 mm. long.

Antennæ 8 jointed, basal joint, 36; 2d, 24; 3d, 36; 4th, 40; 5th, 40; 6th, 28; 7th, 24; 8th, 20.

Habitat on bark of *Ulmus americana*, Lawrence, April, 1898.

I have not seen the original description of *L. celtidis* Ckll. but I received some time ago specimens of *celtidis* from Prof. Cockerell, and have made therefrom a sketch of the antenna for comparison. Antenna of *pruinosus* is eight segmented; the basal segment bearing one minute hair, the second has two prominent hairs, third and fourth joints naked; fifth, six and seventh bearing each one hair; the terminal segment carries seven bristles. The whole member is short and stout. The eight jointed antenna of *celtidis* is longer, more slender, and bristles were observed on the second, fifth and terminal joints, the terminal joint bearing eight. The differences in length of respective segments are shown by the measurements attending. The characteristic structures of the scales, as before stated, are distinctions of moment.

The genera, *Chionaspis* and *Pulvinaria* will be discussed in the next paper upon this subject.

Author's edition, published April 12, 1899.

Description of Some New Forms of Pseudomonotis from the Upper Coal Measures of Kansas.

Contribution from the Paleontological Laboratory, No. 43.

BY J. W. BEEDE.

With Plates—XVIII, XIX.

The genus *Pseudomonotis* is variable. Some authors would include most of the forms under a single species, while others would make at least a dozen species of them. King* recognizes, in the Permian of England, three species; *P. speluncaria, radialis* and *garforthensis*, and seems to be inclined to consolidate the first two of these. Waagen† makes *P. speluncaria* a group and associates the following forms as "varieties or whatever any one may like to call them:" *P. garforthensis, radialis*, and *kazanensis*, besides describing new Indian forms. He previously remarks concerning the species *P. speluncaria*, that it "is one of the most puzzling that exists in palæontology; and though I have studied a great number of specimens of it from the German Zechstein, I have not come to a satisfactory conclusion as to its specific characters. There is no doubt that all the different forms which have been described as *Avic. speluncaria, radialis, garforthensis, kazanensis, hawni, Ostrea matercula*, and many other species are very nearly related to each other, and that in most cases intermediate forms exist which will make a distinction very difficult indeed, but nevertheless I should not like to advocate that all these names should be abandoned, and only the name *Ps. speluncaria* be retained. It would, for instance, give a very inadequate idea of the forms of shells occurring in India, if we were to quote simply the name *Ps. speluncaria*, as just that typical form to which that name was originally applied in

*Mon. Per. Foss. Eng., pp. 154-158.
†Paleontologia Indica, Salt Range Fossils, III Pelecypoda, p. 276, et seq.

Europe is altogether wanting in India. A name given to a shell is simply a means of conveying to other fellow workers a concrete idea of what is meant, and this purpose is not gained if we unite too many different forms under one name."

Meek seems to be very much of the same mind for he says, speaking of a shell of this genus, . "It is not sufficient, however, for specific identification (speaking of the specimen in hand) though it would not be difficult for those whose method of making palæontology easy leads them to include, under the single species, *speluncaria*, all the known forms of this group, to see that species in it."* There is a considerable truth in these statements, but to decide where to draw the line in the present case is none the less difficult.

Some of the American shells of this genus are about as puzzling as those of Europe. Not only are the variations found in the same formation here as there, but, to add to the complications, some of the varieties are found commingled throughout fifteen hundred to two thousand feet, or more, of heavy limestones and shales. In one group it seems that all the apparently hap-hazard variations are as persistent as the general form.

It would seem that in a form with so many variations and having such a great stratigraphic range, certain extreme characters could be selected and separated in to varieties coextensive with each other. This was attempted repeatedly but always failed. Of this group, hereinafter referred to as *P.* cf. *hawni*, we have over two hundred specimens from the upper Coal Measures at Turner, Kansas. In attempting to separate diverse forms, before getting nearly through with the specimens a point is always reached where it is impossible to determine to which form a large number of specimens belong, as they they seem to possess equally the characters of both. This was equally true, no matter what the character of the features selected.

Mr. Shuchert thinks that Meek's *P. hawni* var. *ovata* is not varietally distinct from that species and I am inclined to agree with him on that point.

Following are the descriptions of three new forms referred to of this genus which, I think, are sufficiently distinct to be very easily recognized, especially the first two. I am not clearly satisfied as to whether their characters are of specific or varietal importance, though I think that the first two will prove to be specifically distinct and the third a variety of *P. hawni* Meek. The first two

*Fin. Rep. U. S. Geol. Surv. Neb., p. 200

seem to form a distinct group by themselves, and the second may, possibly, prove to be a variety of the first, though our material does not indicate that such is the case.

Pseudomonotis (?) tenuistriata sp. (?) var. (?) nov.

Shell large, ovate in outline, rather compressed, beak moderately prominent, projecting beyond the hinge which is nearly straight. Anterior ear small, rounded to meet the hinge, rather flat, the shell rising rather abruptly to the swell of the umbo; anterior margin slightly sinuate, antero-ventral margin very broadly rounded to the ventral portion of the shell where it becomes nearly straight, then rounding more abruptly to the posterior ear, which is also rounded to the hinge. Greatest convexity a trifle below the beak, but is very slight there. The surface is marked by many fine, wavy, radiating striæ of uniform size extending from the beak to the ventral margin; occasionally one striation will be a trifle larger than the other on the central part of the shell, but it soon loses itself, and on old individuals the striæ on the ventral border are all about uniform. They increase by interpolation and are rather sharply defined, separated by troughs from one to three times their width, and are generally crossed by fine concentric lines or laminæ. Right valve unknown. Measurements: height 62 mm., length 60 mm.,* convexity 10 mm., length of hinge 23 mm.

Upper Coal Measures; Turner, Wyandotte county, Kansas. Also Topeka; Auburn, Shawnee county, Kansas.

In some respects this shell seems to be related to *P. giganteus* Waagen, from the salt range of India, but differs in being comparatively higher and shorter, and in having much more regular surface markings and less developed ears. It seems well removed from *P. hawni* and *speluncaria* and their varieties.

There seems to be another form of this species or variety, having a much longer hinge, and with the adult much more convex, while the surface is more roughly marked, and the striæ more variable. Two young individuals of these shells are figured in Plate XVIII, figs. 1c and 1d, showing the great length of the hinge and the variation in the ears in the young of that form. The young are not very convex but the older ones are much more convex as a rule, as is shown in figure 1b of the plate referred to. The striæ differ much more in size in the old than in the young individuals, and I am inclined to think that it will prove varietally distinct

*The specimen used as the type is somewhat crushed on the posterior end, making the shell appear longer than it really was. The length given here is that of the specimen in its crushed condition.

from *tenuistriata*, though on account of some of its similarities I leave it here for the present.

Pseudomonotis (?) **robusta sp.** (?) **var.** (?) **nov.**

This shell differs from the preceding in being much more convex and arcuate, in having a longer hinge, higher umbo, beak very much more compressed and scarcely distinct from the umbo, not projecting very sensibly above the hinge. The striæ are more regular and much fainter, and either very indistinct or absent on at least the upper third of the shell. Both concentric wrinkles and lamellæ of growth are distinct. Measurements: length 48 mm., convexity 18 mm., height 42 mm., length of hinge about 28 mm.

In all the specimens we have of this and the preceding species, or variety, the two are easily separated, even the young specimens, and, so far as I am aware it is confined to the lower half or two-thirds of the Upper Coal Measures. Some of the young individuals are more gibbous than the type.

Turner, Wyandotte county, Kansas. Also a specimen collected by the writer at Nebraska City, Nebraska, which is probably of this form.

Pseudomonotis hawni equistriata var. (?) **sp.**, (?) **nov.**

Shell of medium size, ovate in outline, moderately to quite gibbous, a little oblique with respect to the hinge, beak moderately prominent, extending to or a little beyond the hinge which is about half the length of the shell and somewhat arcuate. Umbo quite gibbous. Posterior ear very slightly developed, merging into and forming a slight sinus in the posterior margin; ventral, antero- and postero-ventral margins regularly rounded, anterior margin sinuate in the upper portion on account of the anterior ear which is small and round. The surface is marked by fine, somewhat regular, rather wavy striæ, which increase by interpolation, each fourth to tenth being usually a little larger than the remainder, though not very conspicuously so. Small lamellæ of growth sometimes distinguishable. Some of the striæ extended nearly to the beak. The right valve is flat, or a little concave; otherwise unknown. Measurement, two specimens: Height 31 mm., 34 mm., length 24 mm., 26 mm., convexity 7 mm., 13 mm., length of hinge 12 mm., 16 mm. These two specimens represent the extremes of convexity.

Upper Coal Measures; Turner, Wyandotte county, Kansas.

In general outline this shell seems to be nearly the same as those from the Kansas Permian. However, it differs from this as it

does from *P. hawni* (in a different degree) in its posterior margin, development of the ears, surface markings and flatness of the beak. The study of large collections from the same intervening horizons may prove the two inseparable. If it is true that all the known forms of the genus do completely intergrade, I think that certain extreme forms will still have to be distinguished as varieties or species, though this may not apply to the particular shell under consideration. It is easily distinguished from the two shells just described, but is very closely related to the one following, and indeed may be the the same, though I think not.

Pseudomonotis Cf. **hawni** Meek, Pal. Upp. Mo., p. 54, pl. ii, fig. 5a-c,

This is one of the most varied and puzzling shells in the Coal Measures of the west. Occasionally one is found that approaches *P. hawni* very closely, while on the other hand some are found which resemble closely in external appearance *P. speluncaria* or some of its varieties as figured by King (loc. cit.).

While it varies greatly in size, outline and markings, there are some characters by which it may be possible to distinguish it from *P. hawni.* Two of the more common forms of this shell are figured on plate XIX ff. 1-1f. They show some of the variations in lobing, convexity and general outline. These shells differ, the great majority of them, from *P. hawni*, in being much more convex or gibbous, in having a more or less well defined posterior lobe and in being oblique. Most of the specimens of *P. hawni* that have come under my observation have a beak very much more like that of an *Aviculopecten* than have the shells under consideration. In these, the beak is generally more gibbous and less pointed, in some cases hardly distinct from the general swell of the umbo.

Specimens from the Permian were kindly loaned me for comparison by Professor Charles S. Prosser, and the National Museum through the kindness of Mr. Charles Schuchert. There are also specimens in the collections of the University from Grand Summit, Cowley county, Kansas. The shell under consideration differs from nearly all of these in the nature of the beak and, to some extent, the outline and convexity. However, some specimens sent by Professor Prosser, labelled "Neosho formation, Clements, Kansas," possess a flat beak and show a tendency toward posterior lobing and consequently approach more closely our Coal Measures shell than *P. hawni.* On the whole I am inclined to think that the shell can be separated varietally from *P. hawni*, though I refrain from doing so at present. I have in my collection speci-

mens taken from the Wabaunsee formation, in southwestern Shawnee county, that I am unable to distinguish from *P. hawni*. Shells also occur in the stone upon which the Kansas river dam is built at Lawrence, so similar to the type of *P. hawni* that I think that they are certainly the same species.

There is an interesting specimen figured on plate XIX, figs 2 and 2a, from Grand Summit, which is large, very spinous, and has had the right valve attached. It differs in these respects from *P. hawni*, but not sufficiently, perhaps, to be distingnished from it. The beak is crushed, but appears broad.

That the Turner form, and probably *P. hawni* also, are distinct from *P. speluncaria* is shown by the location of the retractor impressions immediately behind the byssal groove instead of on the ear above it as represented by King (loc. cit.).

Upper Coal Measures; Turner, Wyandotte county, Kansas. Also Clements, Topeka, Lawrence, Kansas.

Note on the Yellow Helium Line.

BY A. St.C. DUNSTAN AND M. E. RICE.

The published results for the distance between the two components of the yellow helium line (5876) are not concordant; and further seem to indicate that the distance is greater for solar helium than for that contained in a vacuum tube. Thus Runge and Paschen (Nature, June 6th, 1895) using a Geissler tube find for the wave lengths of the two components 5875.883 and 5876.206 Ang. units, the latter being the weaker line. Mohler and Jewell (Astrophys. Journ. 3, p. 351-355) find for Geissler tube helium $\lambda_1 =$ 5875.812 and $\lambda_2 = 5876.147$. The distances between the components deduced from these two sets are .323 and .335 respectively. On the other hand, Hale and Ellerman (Astrophys. Journ. 2, p. 165.) and Mohler and Jewell (l. c.) find for solar helium distances of .357 and .341 respectively.

The foregoing results having all been obtained by means of gratings it seemed to the writers desirable to make an independent determination by means of the Interferometer.

For the helium Geissler tubes used in this work the writers are indebted to Dr. E. C. Franklin of this University who kindly placed at their disposal a number of tubes which he made in 1895. One of these was so far superior in brilliancy to the rest that it was used exclusively in the work. The helium was made from Samarskite and seemed to be remarkably pure, the tube showing only the following lines, all of which belong to helium.

6678
5876
5048.4
5016
4922.2
4713.35
4471.75

The tube was placed in series with an adjustable resistance of amyl alcohol, in the secondary of a large induction coil, the primary of which was connected through an adjustable resistance to

the 50 volt alternating current circuit. In this manner the tube could be run for hours without appreciable heating and the steadiness and brilliancy of the light were all that could be desired. It is not known how high the vacuum was, as the tube when made was merely exhausted to the point of maximum brilliancy.

The light coming from the tube was subjected to prismatic analysis, the spectrum falling upon a slit plate. A slight motion of the prisms given by a screw permitted any desired radiation to be thrown upon the slit, from which it passed on into the Interferometer.

Visibility curves were then observed and the results derived by means of the usual formulas.* The mean of several closely agreeing visibility curves taken by each of the writers for the yellow helium line is given very approximately by the equation

$$V = \left(\frac{1.01 + .2 \cos \frac{2\pi x}{9.82}}{1.21} \right)^{\frac{1}{2}} 2^{-\frac{x^2}{36^2}}$$

The line is therefore a doublet, the distance between the components being .351 Angstrom units and the "half breadth" "δ" of each line being .021 Angs. The ratio of the intensities is about 1:10.

The lines at 6678, 5016, and 4471.7 were also analyzed, the result for the blue line (4471.7) being also approximate, however, on account of its extreme faintness.

The red and green lines appear to be single, of half width .027 and .017 respectively; while the blue line is a doublet, the distance between the components being .235 Angs. and the half width of each line about .02 Angs.

It will be seen that the result obtained for the distance between the components of the yellow line differs less than 1 per cent. from the mean of the available measures upon the solar helium line.

*See Phil. Mag. 34 or K. U. Quarterly VI, No. 2, p. 77.

Some Additions to the Cretaceous Invertebrates of Kansas.

BY W. N. LOGAN.

With Plates XX, XXI. XXII, XXIII.

In volume IV of the Kansas Geological survey reports the writer published a preliminary report on the invertebrates of the upper Cretaceous formation of that state. Since the time of the preparation of that report I have made additional collections and present in this article the results of my further investigations. Five of the forms herein described belong to the lower Cretaceous beds, two forms to the Dakota and the remaining forms to the Niobrara division of the upper Cretaceous.

The Dakota in Kansas is subdivided into two groups, the saliferous and the ferruginous. The collections were made from the latter. They consist of casts and impressions in the sandstone.

The Niobrara is subdivided into the Ft. Hays limestone and the Pteranodon beds, the latter being subdivided into the Rudistes beds and the Hesperornis beds. The majority of the specimens were collected from the Rudistes beds. A few forms, however, were collected from the Hesperornis beds.*

The specimens collected consist for the most part of well preserved shells. In a number of the specimens the coloring matter of the periphery of the shell is so well preserved as to present the appearance of a shell in its living state. This fact points to the conclusion that the shells were imbedded in the stratum of chalk before they had weathered to any perceptible degree. From which we are led to believe that the deposition of the forms which compose the chalk was very rapid. Further evidence of the powerful preservative agency of the chalk is also secured. The water in in which these forms were deposited must have been undisturbed by waves or currents else the shells would have worn more or less by corrosion. The water was in all probability deep sea water which did not lie in the scouring path of any deeply flowing cur-

*Four of the specimens herein described were obtained through the kindness of Dr. S. W. Williston of Kansas University. The remaining ones were collected by the writer.

rent. In this still water, on the floor of the sea, these forms lived and died and were quickly buried by the accumulation of the bodies of the protozoans which formed the chalk.

Ostrea kansasensis, n. sp. Plate XX, Figs. 9, 10, 11.

Shell (left valve), irregularly sub-ovate, medium in size, convex, maximum convexity in central area; test thick, thickness greatest at margin; external surface comparatively smooth, yet encircled at irregular intervals by light striæ of growth; interior of valve marked by a deep fossa, in the interior region, otherwise smooth; anterior border slightly curved outward; posterior border short, convex; ventral border deeply concave, not entirely regular in outline curve; external surface sloping in all directions and turning abruptly downward at at the margins.

Measurements:

Length	30 mm
Width	25 "
Height	5 "

Locality: Ellsworth county, Kansas, near Kanapolis.

Geological horizon: Lower Cretaceous.

REMARKS.—This species is based on a number of forms collected by the writer during the past summer from the above named locality. Variability, a characteristic of the species of this genus, is not so well marked in the forms of this species as in some of the associated species. The individual figured is fairly representative of the class. It is found associated with O Wellerii and O. Willistonii.

Ostrea ellsworthensis, n. sp. Plate XXI, Figs. 1, 2.

Shell (left valve), medium size, very slightly convex; exterior surface possessing moderately heavy undulations and ribs; ribs more prominent at margins but not extending in points beyond, crossed at irregular intervals by lines of growth; test moderately thick, thickness not uniform; beak sharp pointed, possessing a small triangular area; ventral border concave; dorsal border irregular; anterior border nearly straight and ending in the first marginal rib; posterior border concave, separated from the ventral border by a marginal rib; interior surface marked by flextures, subumbonal region containing a deep fossa on the margin of which is the muscular impression. Individuals of the species free.

Measurements:

Length	39 mm
Maximum width	40 "
Height	7 "

Locality: Coal Canon, Ellsworth county, Kansas.

Geological horizon: Lower Cretaceous.

REMARKS.—This species is found associated with O. canonensis. Its determination is based upon a number of forms which differ somewhat in general outline, but in other characteristics do not vary to any marked extent.

Ostrea wellerii, n. sp. Plate XX, Figs. 6, 7.

Shell (right valve) long, narrow, nearly flat, irregular in general outline; borders somewhat wavy; test thin, greatest thickness near beak; beak incurved; exterior surface irregularly curved, smooth, umbonal region possessing a horse-shoe shaped depression; general curve of dorsal margin convex but irregularly so; ventral border concave; anterior border rounded; posterior border obtusely triangulate; interior of shell marked by branching depressions; shell considerably larger posteriorly, narrow between beak and central region. Individuals not growing attached.

Measurements:

Length	65 mm
Maximum with	30 "
Height	3 "

Locality: Ellsworth county, Kansas, near Kanapolis.

Geological horizon: Lower Cretaceous.

REMARKS.—The individuals of this speeies are not essentially different in any respect except in general outline, The difference in this particular is not as strongly marked as in many other species. O. wellerii is found associated with O, kansasensis and O. willistonii.

Ostrea willistonii, n. sp. Plate XXI, Figs. 5, 6.

Shell (left valve) orbicular, medium size, elevated, strongly convex, margin radiately ribbed; ribs extending outward into elongated tips, five of which are very prominent; test thick, greatest thickness in marginal region; beak obtusely pointed; dorsal border in the form of an elliptical curve; ventral border slightly concave; anterior border pointed; posterior border obtuse, rounded; interior of valve marked by a deep fossa, having in its posterior part the muscular impression; exterior surface marked by very prominent lines of growth.

Measurements:

Length	40 mm
Width	35 "
Height	12 "

Locality: Ellsworth county, Kansas, near Kanapolis.

Geological horizon: Lower Cretaceous.

REMARKS —This species is based on a number of collected individuals, some of which are less irregular in outline. None of these forms approach the two species with which this one is associated. I do not believe that it can belong to the same

species as O. ellsworthensis, but a collection of a large number of forms may show proper gradations. The forms so far collected by the writer do not point to such a conclusion.

Ostrea canonensis, n. sp. Plate XXI, Figs. 3, 4.

Shell (left valve) less than medium size, partly crescent shaped, moderately convex; margin crenulate; test thin, nearly uniformly so; beak small, pointed; ventral border forming concave curve, smooth, no crenulations; dorsal border forming convex curve, crenulate; posterior border short, rounded; exterior surface ornamented with concentric lines of growth; interior of the shell moderately smooth.

Measurements:

Length	25 mm
Width	20 "
Height	10 "

Locality: Coal Canon, Ellsworth county, Kansas.

Geological horizon: Lower Cretaceous.

REMARKS.—Had I found this species associated with O ellsworthensis I would have called them the same species and the former the young of the latter. For here as in other forms of *ostreidæ* there exists as much difference between the forms of young and adult as there is between these two forms. But as they are not found associated, and several forms of each were obtained, they have been designated as different species.

Ostrea congesta Conrad. Plate XX, Figs. 1, 2, 6.

I am not positive that the form here figured and designated as O. congesta does not differ specifically from that species. Writers upon the Upper Cretaceous of Kansas have applied the name, O. congesta, to two forms which are separated by at least two distinct geological horizons. The first of these two forms occurs in the Ostrea beds of the Ft. Benton group and the second in the lowermost Niobrara beds.

Although these forms differ in many particulars they have certain common characteristics. Both are attached by the whole under surface of the lower valve; both are attached to *Inocerami;* both are members of crowded groups or colonies; both are decidedly irregular in form, consequent upon their method of growth.

They differ in thickness of test, the Benton form being much thinner; they differ in size, the Niobrara form being much larger; they differ in that the muscular impression in the Benton form is indistinct, in the other it is not usually so.

As these two forms do not grade into each other it is fair to assume that they are, at least, varieties if not distinct species. Figures heretofore published best represent the Benton form while

the descriptions correspond to the Niobrara form. For that reason I have figured the Niobrara form and presented two views of the upper valve and one of the lower one. A comparison between this figure and Conrad's type should be made.

Ostrea exogyroidea, n. sp. Plate XX, Fig. 3.

Shell small, thick, elongate, narrow, deep; beak long, curved ventrally, lower valve very capacious, attached by entire lower surface; posterior border short, only slightly rounded; dorsal border possessing a concave curve near the middle portion; ventral border possessing a corresponding convex curve; external surface marked by concentric lines of growth which are not prominent; interior of shell smooth, muscular striæ on rim in anterior region; beak possessing an irregular area which is marked by ridges running parallel to the longitudinal axis of the shell.

Measurements:

Length	30 mm
Width	15 "
Height	10 "

Locality: White Rock creek north of Mankato, Jewell county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—This form is found associated with O. congesta and may be a variety of that species. As will be seen by the description and figures it has marked differences, however. The most noticeable one is that of the irregular, ribbed, umbonal area which is concave beneath. I have collected only a few of the type; further collections may reveal gradational forms.

Modiola, sp.? Plate XX, Fig. 4.

Shell medium size, convex, arcuate, elongately ovate; beak terminal, slightly depressed; anterior end narrow; posterior end dilated and sloping gradually to an almost yet never completely level area at the posterior margin; postero-basal portion sloping equally with posterior; antero-basal margin slightly reflex; basal margin strongly yet uniformly curved; ventral side narrow, precipitous, with shallow depression running from beak to median portion, slightly incurved at margin; ventral margin angular, with apex of angle at median portion; hinge line straight, about half the length of the ventral side; exterior of shell ornamented with more or less prominent lines of growth which are crossed by uniformly radiating ribs. The ribs are wavy and are more prominent in the antero-basal region. They are also prominent in the basal region and scarcely noticeable on the convex area of the valve. On the ventral side they are well marked.

Measurements:

Length	35 mm
Width	15 "
Height	05 "

Locality: Solomon river, near Beloit, Kansas.

Geological horizon: Ferruginous sandstone beds of Dakota Cretaceous.

REMARKS.—This form seems to differ in many respects from any of the already described species of the genus, *Modiola*, but as I have collected only one specimen which has its characteristics so well preserved as to warrant description I hesitate to establish a species on such evidence.

Corbula, sp. Plate XX, Fig. 5.

The shell represented on the plate by figure 5 is apparently a much larger form than any of the described species under the genus *Corbula*. So far, however, as the characteristics of the shell can be made out they point to its position as being under that genus. As its specific characteristics cannot be properly judged from the single specimen in my possession, and as it would be folly to found a determination on such meagre evidence, I prefer simply to mention its occurrence. The form was found in the nature of an impression in a sandstone taken from the Solomon river at Beloit, Kansas. It occurs associated with *Modiola sp.* in the Ferruginous sandstone of the Dakota Cretaceous.

Ostrea incurva, n. sp. Plate XXII, Figs. 1, 3, 5, 6.

Shell (right valve), medium size, thin, convex, length equal to twice the width, convexity increasing slightly from umbonal to central region, then decreasing gradually to posterior margin; exterior surface smooth, not marked by laminations or lines of growth except near dorsal border; interior of shell smooth, muscular impression near ventral border in central region; anterior border short, forming a slightly convex curve; dorsal border irregular but forming on the whole a moderately convex curve; ventral border nearest beak almost straight, but in the posterior part forming a convex curve; beak possessing a truncated area and curved ventrally; borders on each side of beak marked by small transverse ridges; the dorsal side of shell presents an abrupt slope while the slope of the ventral side increases in steepness toward the beak and is marked by one or more ridges with intervening depressions. The postero-ventral region possesses little or no convexity; is nearly flat.

Measurements:

Length	40 mm
Width	20 "
Height	10 "

Locality: White Rock creek, Jewell county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—It may be found expedient to form a new genus for these forms. They certainly present as great generic differences as *Gryphea* and *Exogyra*, but the necessity for such genera has been questioned. Furthermore it is the belief of the writer that as the science of Palæontology advances there will develop a tendency toward the contraction rather than the expansion of the number of genera and species. Should such a condition obtain this genus, if created, would in all probability be among the first to fall.

Ostrea attenuata, n. sp. Plate XXII, Figs. 2, 4.

As will be readily seen from the figures this species is very closely allied to *O. incurva*, figures of which are found on the same plate. The forms are so nearly alike that further description is unnecessary as an enumeration of the points of difference will suffice to give an understanding of the form.

The shell descends from the central line of convexity by equal slopes; the beak is not turned laterally; the dorsal and ventral borders are symmetrical. Otherwise the shells are the same.

It may be that the differences arise from deformations of *O. incurva*, but it is not to be expected that there would be such a uniformity of deformation as is exhibited in the numerous forms collected. They may, however, be merely varieties of the one species. They were collected from the same geological horizon and from the same locality.

Ostrea crenula, n. sp. Plate XXI, Figs. 7, 8, 9.

Shell (right valve), small to medium in size, thin, very convex, ovate in marginal outline; surface rising abruptly from beak, then sloping backwark and upward more gradually to one-third the length of the shell and from that point sloping very gradually downward to the posterior border. From the central line of convexity the sides of the shell fall away rather abruptly, the dorsal more abruptly than the ventral. The exterior surface is marked by ridges and grooves which at the margin assume the form of crenulations. Ventral border nearly straight; posterior border short, rounded, crenulate; dorsal border forming a convex curve; muscular impression sub-central.

The form of the lower valve cannot be made out as it is crushed inside the upper one, but its surface shows striations and its margin is somewhat crenulate. The shell was evidently attached by the

beak of the lower valve. The test of the lower valve is much thinner than that of the upper one.

Measurements:

Length	30 mm
Width	20 "
Height	15 "

Locality: Saline river, Ellis county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—This form is more nearly related to *O. jewellensis* than to any other species. It differs from that species in that its borders are not contracted in front of the beak; that it possesses crenulations and in that it is more convex. The latter might be due to an accident of growth but the other characters remain constant in all the specimens examined.

Ostrea leeli, n. sp. Plate XXI, Figs. 10, 11.

Shell (right valve), thin, irregular in shape, medium size, very slightly convex; surface crossed transversely from beak to posterior border by a series of rounded ridges and more or less deep grooves which show on the inner surface of the shell as ridges; beak sharply pointed, turned a little toward ventral margin; anterior portion of the shell forming a short neck to the expanded posterior portion.

The ventral side of the shell slopes more than the somewhat abrupt dorsal side; ventral border slightly concave; dorsal border possessing a deep inward curve; posterior border broadly rounded. Lower valve unknown.

Measurements:

Length	40 mm
Width	25 "
Height	10 "

Locality: Solomon river, Phillips county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—Only a few specimens of this species have been collected, and these from one locality. The specimen figured is the best preserved one of the collection.

Ostrea lata, n. sp. Plate XXII, Figs. 7, 8, 9, 10

Shell (right valve) thin, ablong, slightly convex; beak pointed and turned downward; surface of shell rising moderately abruptly to anterior one-third of shall, thence sloping very gradually to the posterior border; sides of shell symmetrical; exterior surface marked near the borders by light lines of growth; ventral border nearly straight; dorsal border slightly convex; posterior border forming an obtuse point.

Lower valve thin, flat, thickness greatest at the beak; underside of beak showing flat, smooth surface of attachment.

Both valves are marked by a deep notch in the antero-dorsal region.

Measurements:

Length	46 mm
Width	25 "
Height	08 "

Locality: Saline river, Ellis county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—Figures 7 and 10 represent views of an adult, while 8 and 9 are young individuals. The groove on 9 is probably due to pressure.

Ostrea jewellensis, n. sp. Plate XXII, Fig. 11.

Shell (right valve) thin, medium size, ovate, convex; greatest convexity a little more than one-third the distance back from the beak, shell surface sloping gradually from this point to the posterior border and more abruptly toward the beak; sloping still more abruptly to each side and ending in wing-like areas, which are almost flat but are crossed by oblique ridges and depressions. The beak is straight, ending in a triangular form with a smooth area on the under side. The borders on each side of the beak are turned inward a little and crossed by transverse ridges. The exterior surface of the shell is smooth, not showing lines of growth but more or less prominent ridges on marginal areas; posterior border rounded in convex curve; dorsal and ventral borders alike forming convex curves with depressions near the beak.

Measurements:

Length	35 mm
Width	15 "
Height	8 "

Locality: White Rock creek, Jewell county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—This form may be a variety of *O. incurva*. However, among a number of specimens examined there appeared no gradational forms.

FAMILY OSTREIDÆ.

Pseudo-perna, nov. gen.

Shell varying in size, shape, and thickness; beak of lower valve split transversely into two equal parts; hinge line of right valve possessing at a short distance from the beak a projection, between which and the beak the border is crossed by short rounded transverse ridges; surfaces vary from smooth to deeply imbricated: margins in some species reflex and crenulate,

Pseudo-perna rugosa, n. sp. Plate XXIII, Figs. 1, 2, 3, 4, 5.

Shell (right valve), small, moderately thick, ovate, convex, line of greatest convexity forming an oblique angle; umbonal region smooth, surface of shell rising gradually from beak to dorso-central region, thence sloping to ventro-posterior border; postero-dorsal slope marked by deep grooves formed by concentric lines of growth; inner surface smooth; test of practically the same thickness throughout the entire extent of the shell; beak turned toward the ventral border; hinge line long, possessing near the beak transverse ridges which are rounded and separated by slight depressions.

The ventral border of the shell is straight. The dorsal and the posterior borders form parts of the same curve which presents its greatest convexity in the mid-dorsal region. The muscular impression is large and ornamented by several sets of concentric striæ.

Measurements:

Length	35 mm
Width	25 "
Height	10 "

Locality: Outcrop near Burr Oak, Jewell county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—I thing the figures on the accompanying plate represent three stages in the individual development of this species. Fig. 3 represents a very young individual. Figs, 1 and 2 represent two views of an older one, while 4 and 5 are views of an adult. The adult form of the type has on the internal surface certain star-like forms which seem to be Crustaceans, but I have been unable to find anything analogous to them in the literature of palæontology.

Pseudo-perna torta, n. sp. Plate XXIII, Figs. 6, 7.

Shell (right valve), ovate-triangulate to oblong, almost flat, slightly convex in umbonal region; beak not prominent; test thin; posterior border reflex and crenulate in some individuals; dorsal border crenulate in some individuals, attributed to accident of growth; exterior surface of shell smooth or in some individuals marked by fine lines of growth; interior surface smooth.

The hinge line is not prominent but possesses near the beak a few rounded ridges extending across the edge of the border, with no ligamental groove as in the last species.

The ventral border varies from convex to almost straight; dorsal border also nearly straight; posterior border broadly rounded; anterior border varying from angular to broadly rounded.

Lower valve thin, greatest thickness near margin, nearly flat, shell attached apparently by the entire under surface of the valve.

Measurements:

Length .... 38 mm
Width.. 30 "
Height .... 6 "

Locality: Solomon river near Marvin, Phillips county, Kansas, and Smoky Hill river, Trego county, Kansas.

Geological horizon: Rudistes and Hesperornis beds, Niobrara Cretaceous.

REMARKS.—All the species of this genus have the coloring matter of the periphery of the shell well preserved. So well, indeed, that they have the appearance of shells just taken from the ocean. This fact leads to the following conclusions: First, that the shells were imbedded in their matrix of chalk before they had weathered even to a slight degree; second, that the chalk acts as a preservative agent for the coloring matter; and that the chalk forms must have been deposited at a very rapid rate in order to have produced the first result.

Pseudo-perna attenuata, n. sp. Plate XXIII, Figs. 8, 9.

Shell (right valve), thin, oblong, convex, convexity greatest along median line, beak sharp pointed; turned toward ventral border; hinge line long, possessing near the beak a very prominent projection; area between the beak and projection occupied by several transverse ridges, remainder of ventral border straight; exterior surface smooth except near the margins where it is marked by concentric lines of growth.

The posterior border is truncate; dorsal border broadly curved, anterior border short, rounded. The interior of the shell is smooth. The muscular impression is small.

Measurements:

Length .... 41 mm
Width .... 27 "
Height .... 7 "

Locality: Solomon river, Phillips county, Kansas.

Geological horizon: Rudistes beds, Niobrara Cretaceous.

REMARKS.—The ventral border projection is more prominent in this species than in any other of the genus. The general shape of the shell corresponds more nearly to *P. rugosa* but the test has not half the thickness.

Pseudo-perna orbicularis, n. sp. Plate XXIII, Figs. 10, 11.

Shell (left valve), large, orbicular, convex, beak split horizontally into two equal parts, turned slightly toward ventral border; exterior surface of shell smooth except in the posterior region where it is marked by concentric lines of growth; ventral border irregular, crenulate and slightly reflex; posterior border nearly straight; dorsal border moderately convex; anterior border pointed; test ot

shell very thick, almost uniformly so; convexity greatest along mid-dorsal line.

Measurements:

Length	45 mm
Width	38 "
Height	15 "

Locality: Saline river, Ellis county, Kansas.

REMARKS.—This is the largest species of the genus. The characteristic left valve is entirely different from the other species as will be seen from the descriptions. Unfortunately no left valves of this species have been collected.

On Tetracaulodon (Tetrabelodon) Shepardii, Cope.

BY GEORGE WAGNER.

With Plates XXIV, XXV.

In the paleontological museum of the University of Kansas is the mandible of a mastodon, from the Loup Fork beds of Phillips county, Kansas. It consists of a nearly complete left ramus, with the last molar in place. (See Plate XXIV). The jaw agrees so completely with *Tetrabelodon shepardii*, described by Cope*, that it must be considered as belonging to that species. The jaw is very well preserved. The tusk is not present, but its alveolus is plainly seen, and indicates a tusk slanting downward at quite a steep angle. The symphysis is short and abruptly descending.

The last molar has four crests and quite a prominent keel, the internal half of each crest is slightly in advance, the outer halves of the first three crests are worn into trefoils. The tooth tapers *very* slightly to the rear; there is but little cement in the valleys; the cingulum is prominent.

In front of this molar the alveolus is empty. The fore part of the ramus is elevated, descending steeply to the symphysis. Below this elevation, about one-fourth the way down the side, is the mental foramen, 10 mm in diameter. The curve between the coronoid and condyloid process ascends gradually, and is not deeply notched, as is the case in *Mastodon Americanus*.

Measurements:

Length of ramus and symphysis	565	mm
Length of ramus to symphysis	475	"
Depth of ramus, posterior end of last molar	130	"
Depth of ramus, anterior end of last molar	120	"
Depth of ramus, at elevation	165	"
Width of ramus, posterior end of last molar	112	"
Width of ramus, anterior end of last molar	90	"
Diameter of last molar, anterior, posterior	180	"

*A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado, p. 57. (From Fourth Annual Report, Geological Survey of Texas.)

Diameter of last molar, transverse, anterior end of third crescent .... 64 mm
Diameter of last molar, transverse, anterior end of fourth cresent .... 60 "

A portion of a right ramus presented to the museum by Mr. ———, and collected in the ——— beds of South Dakota, is somewhat larger than the foregoing, but agrees with it very well otherwise, except that the elevation in front is less pronounced. There are two teeth, too much worn for exact comparison, the posterior one badly broken. The mental foramen is located in the same position as in the foregoing, but there is another foramen about 45 mm behind and 20 mm below the first. This specimen is certainly a *Tetracaulodon* (*Tetrabelodon*) identical with or very closely allied to *shepardii.*

Measurements:

Depth of ramus, anterior end of posterior tooth .... 140 mm
Depth of ramus, at elevation .... 155 "

Through the kindness of Prof. Grimsley of Washburn college, Topeka, I have had the privilege of studying several specimens from the museum of that institution, coming from the same bed as the jaw first mentioned. These specimens agree in almost every respect with those in this museum, and must be considered as being conspecific with them.

1. Parts of two maxillaries, connected with small portions of th palatines, and containing the two first molars on each side. The teeth on the right side are more worn than those on the left. The front tooth is two-crested, the second three-crested with a slight indication of a fourth crest. The inner half of each crest is worn to a trefoil, the outer half is oval with slight buttresses, cingulum distinct. Outer halves of crests slightly in advance. (See Plate XXV.)

Measurements:

Diameter of first molar at base, antero-posterior .... 55 mm
Diameter of first molar at base, transverse .... 45 "
Diameter of second molar at base, antero-posterior. .... 105 "
Diameter of second molar at base, transverse .... 70 "

The suture between the two halves of the palate is straight and distinct. The palatines extend slightly forward of the base of the second molar. The upper portions of the maxillaries are much honeycombed; a small portion of the nasal passage is shown.

Measurements:

Diameter of palate to edge, anterior ends of second molars.. 185 mm
Combined width of palatines .... 26 "

2. Two upper last molars, belonging to opposite sides, seemingly of the same jaw. Four crests and trace of fifth. Cingulum distinct, especially on inner face. Inner halves of first three crests trefoiled. (See Plate XXV).

Measurements:

Diameter of right at base, anterio-posterior........... 160 mm
Diameter of right at base, transverse, posterior end of second crest.. 85 "
Diameter of left at base, anterio-posterior .... 170 "
Diameter of left, transverse, posterior end of second crest 90 "

3. Some specimens of tusks in the Washburn museum I have not seen, but Mr. F. J. Titt of that college has kindly sent me the following notes thereon:

Specimen A. (See cross section in Fig. A.), a fragment at the end of a tusk 18½ inches long, with a vertical diameter, at the large end, 1½ inches. This specimen has only a very small portion of the enamel adhering to it.

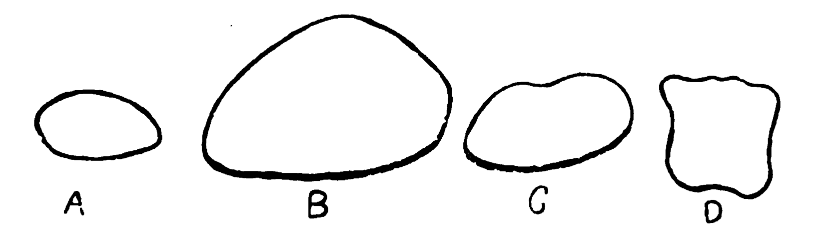
Specimen B. (See cross sections in Fig. B.), a fragment 16 inches long, representing probably an injured tip.

Measurements:

Vertical diameter, large end .... 5 inches
Vertical diameter, small end .... 3½ "
Horizontal diameter, large end...................... 3½ "
Horizontal diameter, small end .... 2 "

Specimen C. (See cross section in Fig. C.), a fragment of a tip 16½ inches long, very slightly curved. Its two diameters are equal, 2½ inches. The tusk is characterized by ridges and shallow grooves varying in width from ¼ to 1 inch.

These tusks all show bands of enamel running the length of the tusk and covering about ⅓ the circumference.



SYNONYMY.—An attempt to construct a synonymy which would be anywhere near complete, would lead too far afield. I shall record therefore, only the names pertinent to this discussion.

TETRACAULODON SHEPARDII, COPE.

?? Tetracaulodon mastodon toideum, Godman; Trans. Am, Phil. Society, N. S., Vol. 3, p. 478, (1830).

? Mastodon shepardii; Leidy, Proc. Ac. Nat. Sc., Phila., 1870, p. 98.

? Mastodon shepardii; Leidy, Proc. Ac. Nat. Sc., Phila., 1872, p. 142.

? Mastodon obscurus; Leidy, Rept. U. S. G. and G. Survey of Terr., Vol. 1, p. 330, Plate 21, (1873).

Mastodon shepardii; Cope, Am. Naturalist, 1884, p. 525.

Dibelodon shepardii; Cope, Proc. Am. Phil Soc., Vol. 22, p. 5, (1884).

Tetrabelodon shepardii; Cope, Preliminary Report on the Vertebrate Paleontology of the Llano Estacado, p. 57, Plate 15.

It requires no extended study to discover that in the taxonomy of mastodons a confusion little short of hopeless reigns supreme. Much of this is due to the usual fragmentary state of specimens; but the fact that species after species has been erected on the evidence of single, often fragmentary, teeth, does not help matters. Considering the peculiarities of elephantine dentition, and the seemingly very great tendency toward variation and intergradation such species must in most cases be considered worthless, except where corroborated by further material.

If it shall ever be possible to make a study of American mastodons as a whole, with ample material, a considerable reduction in the number of species may be looked for.

In 1830 Godman described the genus *Tetracaulodon*, with characters that seem perfectly valid. The genus was recognized for ten or fifteen years and then resubmerged in *Mastodon*. The type species may be the same as the one here under discussion, but at present I am unable to verify the supposition.

In 1870 Leidy based his *M. shepardii* on a single specimen of tusk, and that a fragment only six inches long. It can hardly be considered a valid name. Later on he merged the species into *M. obscurus*, a species based on material almost equally insufficient, a single tooth.

In 1884 Cope revived the species *shepardi* without, however, any further characterization. Later in the same year he made it the type of his genus *Dibelodon*. Lastly in 1893, he referred to this species (*shepardii*, he now spells it), a nearly complete lower jaw from Texas, and as this showed the presence of lower tusks he transferred the species to his genus *Tetrabelodon*. Here he also gave for the first time, an adequate description, and the species, it seems to me, should date from here. The genus name, however, cannot stand. The four-tusked genus called by Cope, *Tetrabelodon*, is certainly well characterized, but its characters were well stated

by Godman more than a half of a century earlier, and his name is entitled to precedence. That *Dibelodon* is a valid genus I very much doubt. I am very much inclined to believe that the forms referred to it are only females of *Tetracaulodon.*

How many species of *Tetracaulodon* we have is yet to be decided. *T. euhypodon,* Cope is probably synonymous with *shepardii,* as may be *T. productus. Mastodon floridanus,* Leidy*, agrees in practically all points with *T. shepardii.* I hesitate in referring it to that species only on account of a more pronounced tubercular structure of the teeth in *M. floridanus* (which difference may be less than the plates seem to indicate), and on account of the fact that the specimens of last lower molars described by Leidy are fully 25 per cent larger than in any recorded specimen of *T. shepardii.*

To Prof. Williston I am much indebted for constant aid in this as in other investigations, as well as for the use of specimens and literature. To Prof. Grimsley of Washburn College I am thankful for the specimens loaned to me, and to Mr. T. J. Titt of the same college, I am much indebted for the descriptions and measurements of the tusk fragments.

*Trans. Wagner Free Institute of Science. Vol. 4, p. 15, (1896).

Cupro-Goslarite, a New Variety of Zinc Sulphate.

BY AUSTIN F. ROGERS.*

The mineral described in this note was found by the writer at Galena, Cherokee county, Kansas, in August, 1898, while engaged upon the University Geological Survey of Kansas. It occurs as an incrustation on the wall of one of the abandoned zinc mines known as the "Sunshine" diggings, and has been formed since the mine was opened. In the same wall were found sphalerite and chalcopyrite, by the oxidation of which the mineral was no doubt produced. As these minerals occur throughout the district, the substance here described may be found in any of the mines of the region.

The properties of Cupro-Goslarite are as follows: Translucent; light greenish-blue in color; hardness, 2; luster, vitreous; brittle. It is almost completely soluble in cold water. On exposure to the air loses a part of its water and becomes white. Before the blow-pipe fuses readily to a black non-magnetic mass, the flame being colored green.

As a comparatively large amount of copper was indicated by a qualitative chemical examination, it was thought desirable to make a complete quantitative analysis of it. Zinc sulphate, $SnSO_4.7H_2O$, loses six molecules of water at 100°C and the seventh at 260°C. As it is difficult to obtain perfectly anhydrous zinc sulphate without driving off a part of the acid, the substance under examination was held at a temperature of 100°C for three hours. The total amount of water as given below was calculated by assuming that one molecule of water was retained at this temperature. Copper, zinc and iron were determined by well known methods and calculated as oxids and sulphates.

The analysis is as follows:

*Published with the consent of the Director of the University Geological Survey of Kansas.

		Which is equal to	
ZnO	23.83	$ZnSO_4$	45.16
CuO	6.68	$CuSO_4$	12.48
FeO	0.13	$FeSO_4$	0.27
H_2O	41.76	H_2O	41.76
SO_3	(27.02)	Insoluble	0.58
Insoluble	0.58		
Total	100.00	Total	100.25

The only other goslarite containing copper known to the writer is one from the Gagnon mine, Butte, Montana. The analysis by Hildebrand* is as follows:

ZnO=(27.56); CuO=0.12; (Mn,Fe)O=0.30; SO_3=28.09; H_2O=43.93; total=100.00.

Mineralogical Laboratory, University of Kansas, April 12, 1899.

*Quoted by Pearce, Proc. Col. Soc., 2, 12, 1895.

PLATE XIII.

Fig. 1. *Lecanium macluræ* nov. sp. on osage orange. Adult female on center of twig, immature female on side of twig. Enlarged six times.

Fig. 2. *Lecanium macluræ* nov. sp. Antenna, prothoracic leg, mesothoracic leg, and metathoracic leg of adult female. Claws of pro- and mesothoracic legs enlarged beneath respective members. Two digitules of claw seen only in mesothoracic leg. Enlarged about 125 times.



Fig. 1.

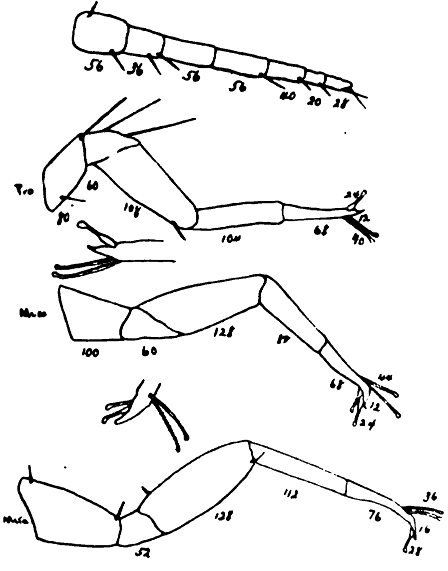


Fig. 2.

Ella Weeks, del. ad nat.

PLATE XIV.

Fig. 1. *Lecanium canadense*, Ckll. on *Ulmus americana*. Dorsal view of female. Enlarged ten times.

Fig. 2. *Lecanium canadense*, Ckll. on *Ulmus americana*. Lateral view of female. Enlarged ten times.

Fig. 3. *Lecanium canadense*, Ckll. Antenna, and metathoracic leg of female. Enlarged about 125 times.

Fig. 4. *Lecanium kansasense*, nov. sp. Dorsal view of female, on *Cercis canadensis*. Enlarged six times.

Fig. 5. *Lecanium kansasense*. Antenna and leg of female. Enlarged about 125 times.

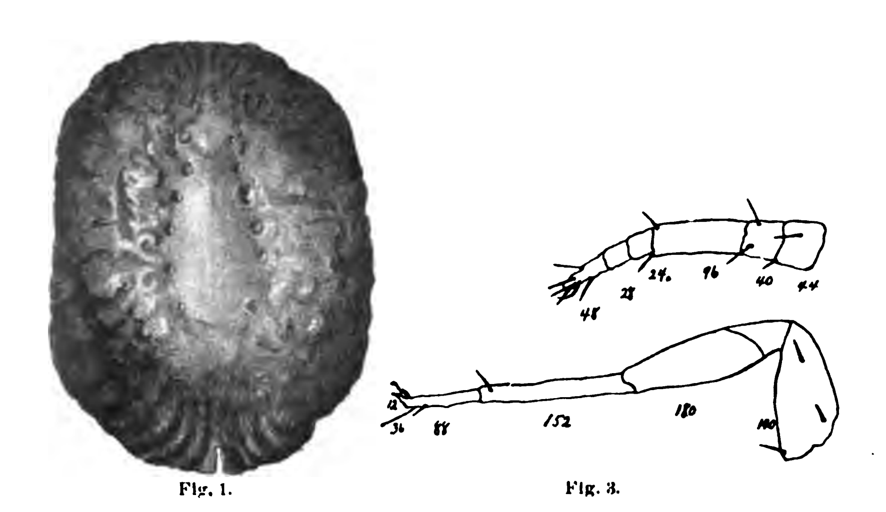


Fig. 1.

Fig. 3.



Fig. 2.



Fig. 4.

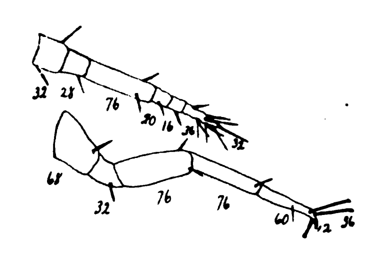


Fig. 5.

Ella Weeks, del. ad nat.

PLATE XV.

Fig. 1. *Lecanium cockerelli*, nov. sp. Dorsal view of female on *Ulmus americana*. Enlarged 12 times.

Fig. 2. *Lecanium cockerelli*, nov. sp. Antenna and leg of female on *Ulmus americana*. Enlarged about 125 times.

Fig. 3. *Lecanium cockerelli*, nov. sp. Antenna and leg of female on *Juglans nigra*. Enlarged about 125 times.

Fig. 4. *Lecanium armeniacum* Craw. *a*. Antenna of female bearing six joints; *b*, antenna of female bearing seven joints; *c*, leg of female.

Attention is called to the fact that bristle extending from the distal end of joint 3, in the seven-jointed variety, was not found in any of the 13 specimens examined of the six-jointed variety, extending as would be expected from the middle of the long 3d segment. The long 3d segment always bore hairs at distal end and nowhere else.

Fig 1.

Fig 2.

Fig. 3.

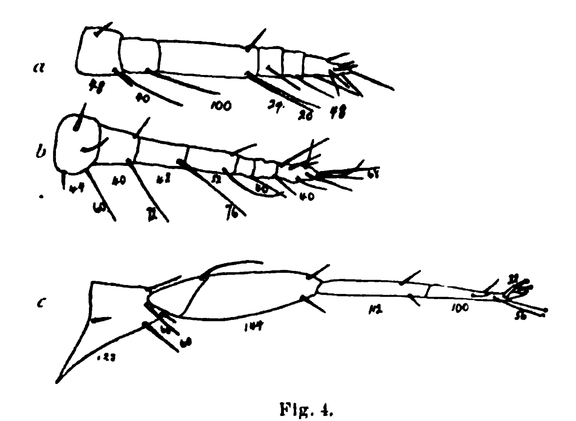


Fig. 4.

Ella Weeks del. ad nat.

PLATE XVI.

Fig. 1. *Lecanium hesperidum* L. Dorsal view of female on *Citrus* sp. Enlarged 15 times.

Fig. 2. *Lecanium hesperidum* L. *a*. Antenna of female on *Citrus* sp. Enlarged about 125 times. *b*. Antenna of female as delineated by Berlese (Tracing sent by Professor Cockerell).

Fig. 3. *Lecanium hesperidum* L. *a* Antenna of female. *b*. Antenna of female drawn to show difference in sizes. *c*. Leg of female. On *Hedera helix*. Enlarged about 125 times.

Fig 4. *Lecanium coffeæ* Walker. Antenna and leg of female.

Fig. 5. *Lecanium oleæ* Bernard. Antenna and leg of female, 5th joint not always distinct. On *Nerium oleander*. Enlarged about 125 times.

Fig. 1.

Fig. 2.

Fig. 3.

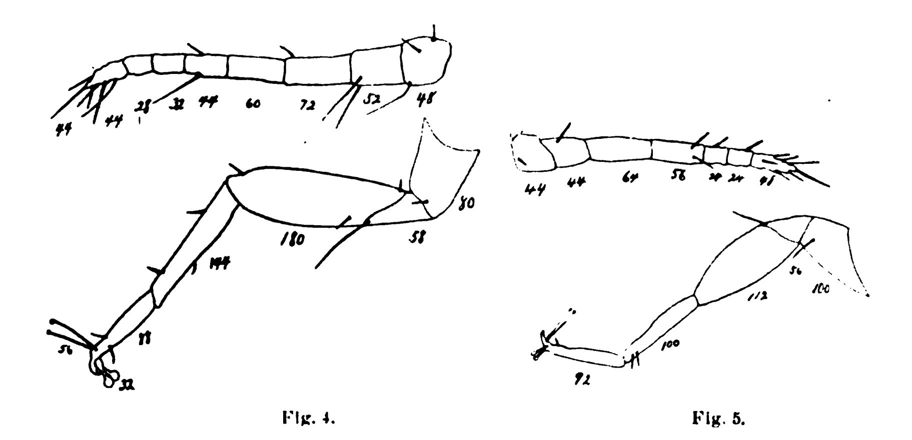


Fig. 4.

Fig. 5.

Ella Weeks, del. ad nat.

PLATE XVII.

Fig. 1. *Lecaniodiaspis celtidis* Ckll , sub. sp. *pruinosus* sub. sp. nov. Dorsal view of female on *Ulmus americana*.

Fig. 2. *Lecaniodiaspis celtidis* Ckll. sub. sp. *pruinosus* sub. sp. nov. Antenna of female. Enlarged about 125 times.

Fig. 3. *Lecaniodiaspis celtidis* Ckll. Antenna of female. Enlarged about 125 times.

Fig. 4. *Lecaniodiaspis* (?) *parrotti*, nov. sp. Dorsal view of female on *Aesculus glabra*. Enlarged 12 times.

Fig. 5. *Lecaniodiaspis* (?) *parrotti*, nov. sp. lateral view of female. On *Aesculus glabra*. Enlarged 12 times.



Fig 1.

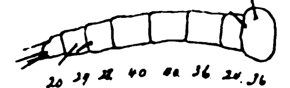


Fig. 2.

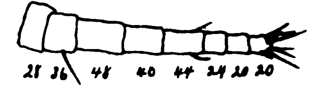


Fig. 3.



Fig. 4.



Fig. 5.

Ella Weeks, del. ad nat.

PLATE XVIII.

Fig. 1. *Pseudomonotis tenuistriata.* Left valve of type. Postero-ventral portion crushed, probably giving it undue prominence. The striæ are finer, and more crinkley than represented in drawing. About natural size.

Fig. 1a. Outline showing convexity of the same.

Fig. 1b. Outline showing the convexity of the adult long-hinged forms.

Figs. 1c and d. Young specimen of the long-hinged form showing different degrees of development of the hinge and ears. About natural size.

Fig. 2. *Pseudomonotis robusta.* Left valve of type. The striæ are finer and more wavy than represented, and the upper third is practically glabrous, only the faintest traces of striæ being present. About natural size.

Fig. 2a. Anterior view of the same shell, showing gibbosity and arcuity of shell, as well as concentric lines of growth. About natural size.

Figs. 2b and 2c. Anterior and lateral views of the left valve of a young individual of the above shell. About natural size.

Fig. 3. *Pseudomonotis hawni equistriata.* Left valve of type. A little less than natural size.

Figs. 3a and 3b. Anterior views of two left valves showing variation in convexity and indistinctness of beak. About natural size.

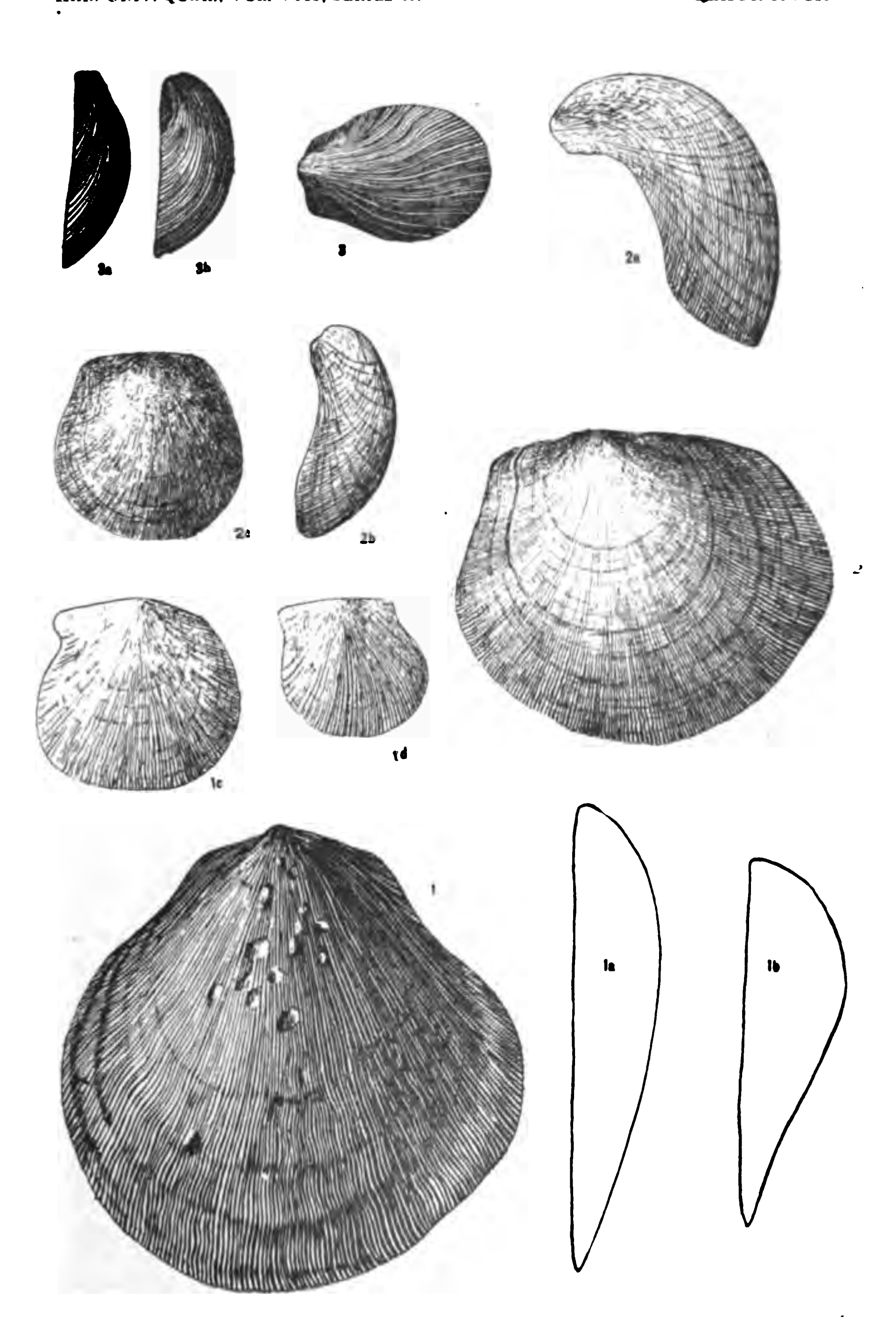

3a
3b
3
2a
2c
2b
2
1c
1d
1
1a
1b

PLATE XIX.

Fig. 1. *Pseudomonotis* Cf. *hawni.* Left valve showing posterior lobation and contortion of costæ and striæ. The lobe is not separated from the rest of the shell very distinctly in most of the specimens, being more of a prolongation of the postero-ventral part backwards. Natural size.

Fig. 1a. Interior of right valve of a specimen, in all probability of this form, showing the very deep byssal sinus and the location of the retroactor scars behind the byssal sinus instead of on the ear above. It also shows the adductor scar and traces of radiating ribs are visible on the interior. Natural size.

Figs. 1b and 1e. Outlines illustrating degrees of gibbosity of these shells.

Fig. 1d. Another specimen showing more clearly the radiating striæ and costæ and possessing a more distinct posterior lobe.

Figs. 1c and 1f. Views from above of two specimens of this shell showing the form of the umbo.

Figs. 2 and 2a. Right and left valves of a specimen of *Pseudomonotis hawni* (?) showing great spinosity and broad beaks (beaks are crushed somewhat) and that the left valve had been attached. Byssal sinus indistinct. Natural size.

Fig. 3. Surface markings of *Pseudomonotis tenuistriata* showing the lamellæ extending farther down toward the ventral part on the ridges than in the furrows, in marked contrast to certain other not distantly related, genera of shells in which the lamellæ in the furrows are more produced than on the ridges. Highly magnified.

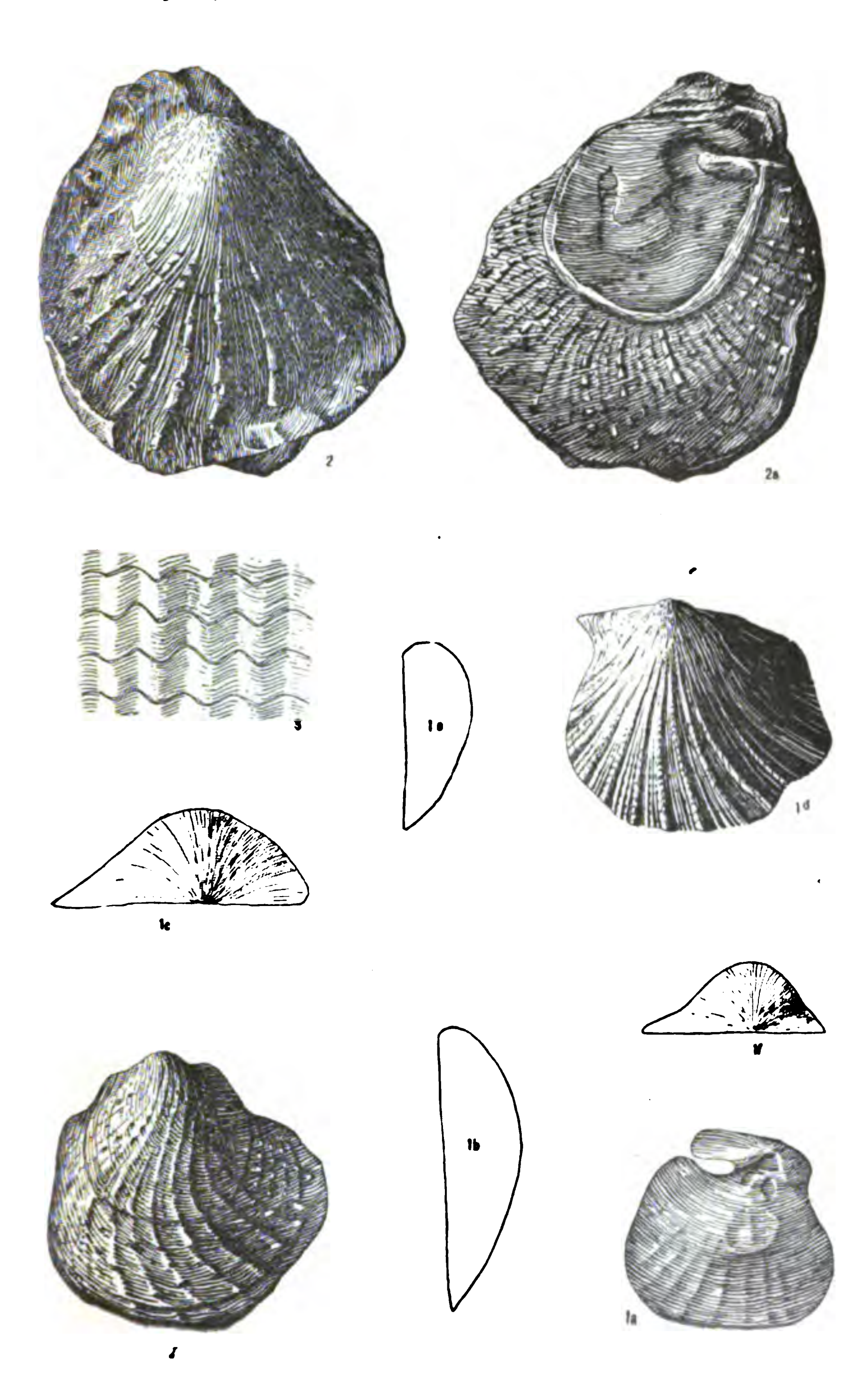

2
2a
3
1e
1d
1c
1f
1b
1
1a

PLATE XX.

Ostrea congesta, Conred.

Fig. 1. Interior of right valve.
Fig. 2. Exterior view of right valve.
Fig. 6. Interior of left valve.

Modiola. sp.

Fig. 4. Exterior of right valve.

Ostrea exogyroides, n. sp.

Fig. 3. Interior of left valve.

Corbula, sp.

Fig. 5. Interior of one valve.

Ostrea wellerii, n. sp.

Fig. 7. Interior of right valve.
Fig. 8. Exterior of left valve.

Ostrea kansasensis, n. sp.

Fig. 9. Exterior of left valve.
Fig. 10. Exterior of left valve.
Figr 11. Interior of left valve.

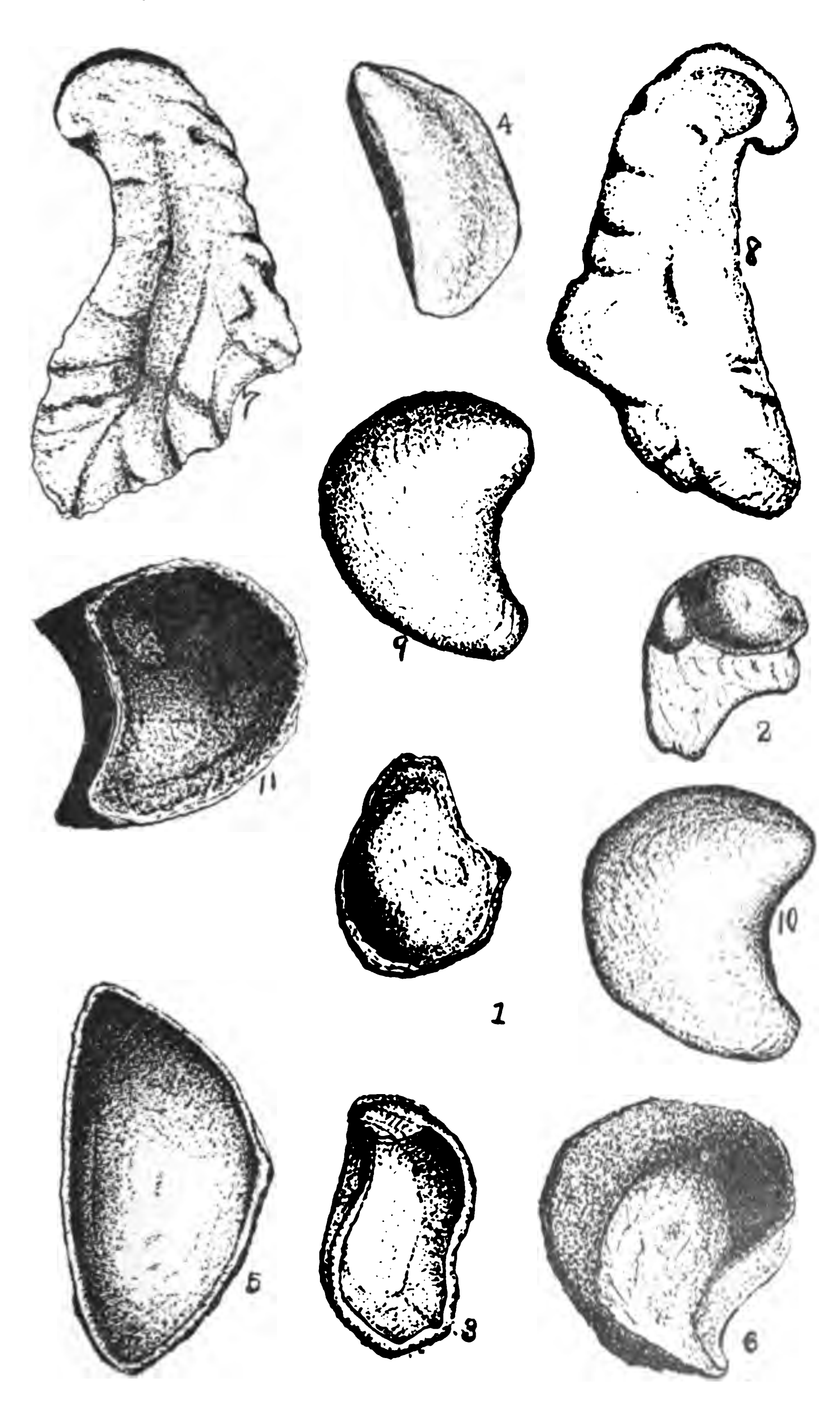

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3
6

PLATE XXI.

Ostrea ellsworthensis, n. sp.

Fig. 1. Interior of left valve.
Fig. 2. Exterior of left valve.

Ostrea canonensis, n. sp.

Fig. 3. Exterior of left valve.
Fig. 4. Interior of left valve.

Ostrea willistonii, n. sp.

Fig. 5. Interior of left valve.
Fig. 6. Exterior of left valve.

Ostrea crenula, n. sp.

Fig. 7. Exterior of right valve.
Fig. 8. Interior of right valve.
Fig. 9. Exterior of right valve.

Ostrea leei, n. sp.

Fig. 10. Exterior of right valve.
Fig. 11. Interior of right valve.

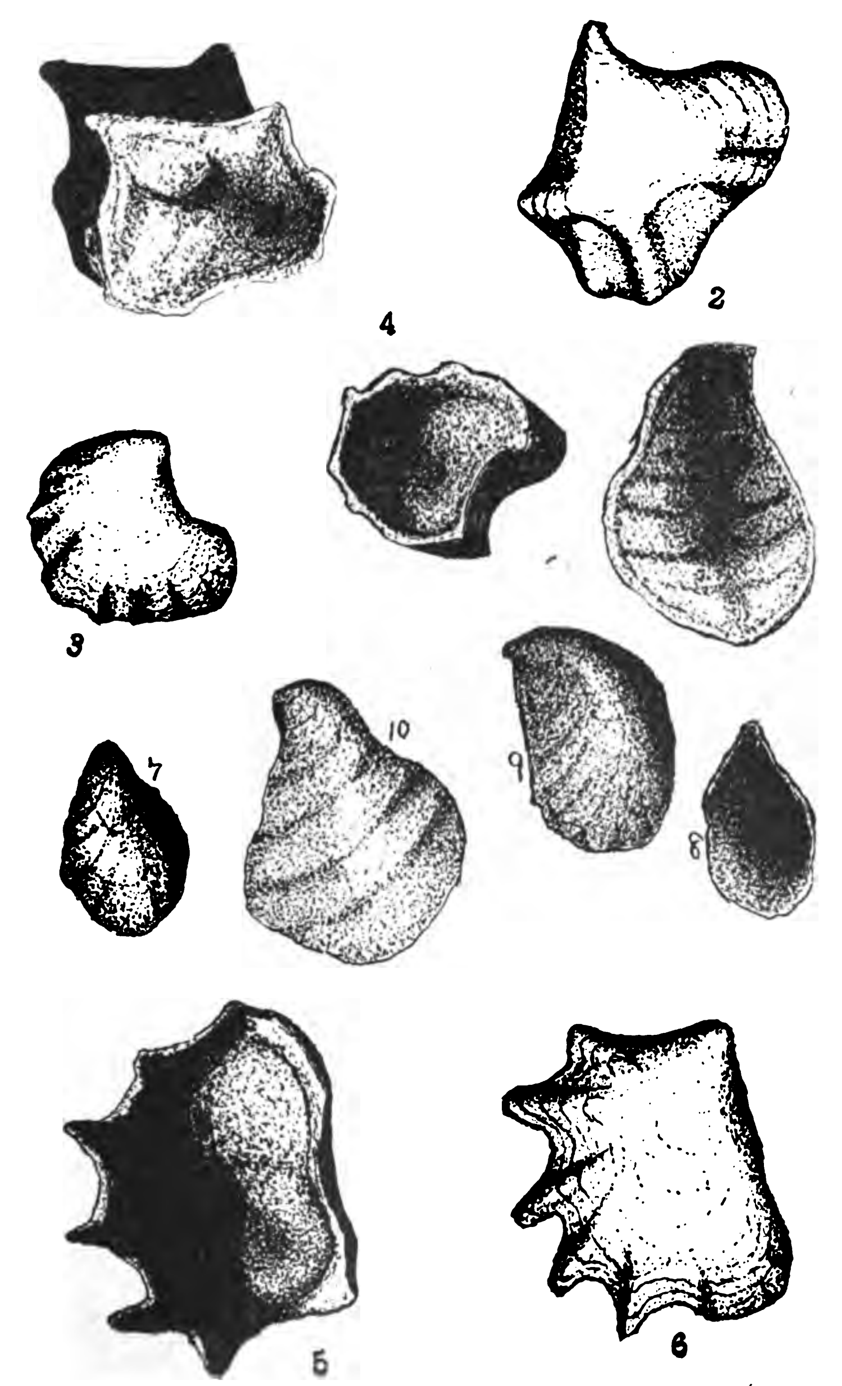

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PLATE XXII.

Ostrea incurva, n. sp.

Fig. 1. Exterior of right valve.
Fig. 3. Exterior of right valve.
Fig. 5. Interior of right valve.
Fig. 6. Exterior of right valve.

Ostrea attenuata, n. sp.

Fig. 2. Exterior right valve.
Fig. 4. Interior of right valve.

Ostrea lata, n. sp.

Fig. 7. Exterior of right valve, adult.
Fig. 8. Exterior of right valve, young.
Fig. 9. Exterior of right valve, young.
Fig. 10. Interior of right valve, adult.

Ostrea jewellensis, n. sp.

Fig. 11. Interior of right valve.

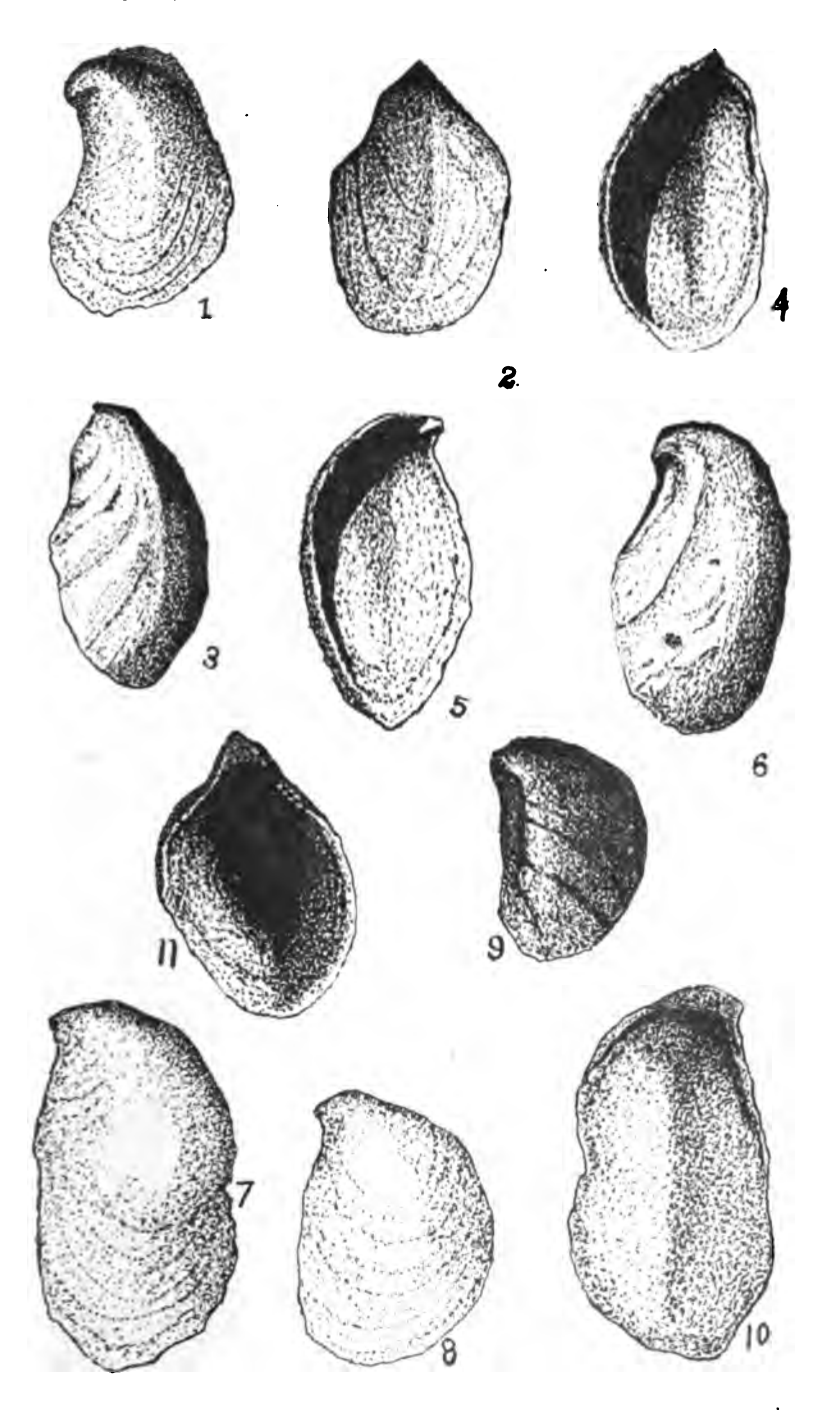

1
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PLATE XXIII.

Pseudo-perna rugosa, n. sp.

Fig. 1. Exterior of right valve, young.
Fig. 2. Interior of right valve, young.
Fig. 3. Exterior view of right valve, very young.
Fig. 4. Interior view of right valve, adult.
Fig. 5. Exterior view of right valve, adult.

Pseudo-perna torta, n. sp.

Fig. 6. Exterior view of right valve.
Fig. 7. Interior view of right valve.

Pseudo-perna attenuata, n. sp.

Fig. 8. Interior of right valve.
Fig. 9. Exterior of right valve.

Pseudo-perna orbicularis. n. sp.

Fig. 10. Exterior of left valve.
Fig. 11. Interior of left valve.

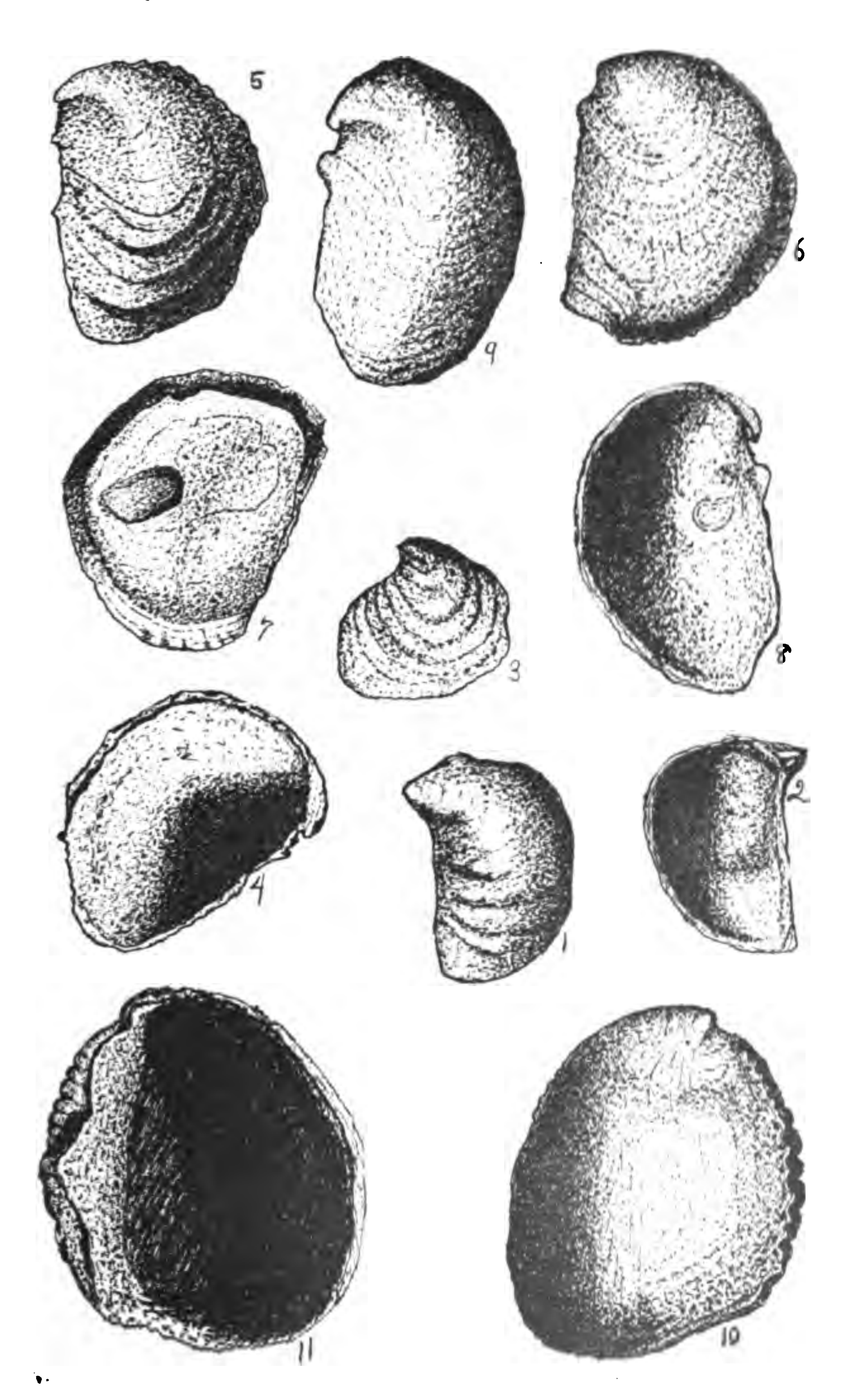

5
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6
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4
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PLATE XXIV.

Left ramus of mandible of *Tetracaulodon Shepardii*, Cope; Phillips county, Kans.

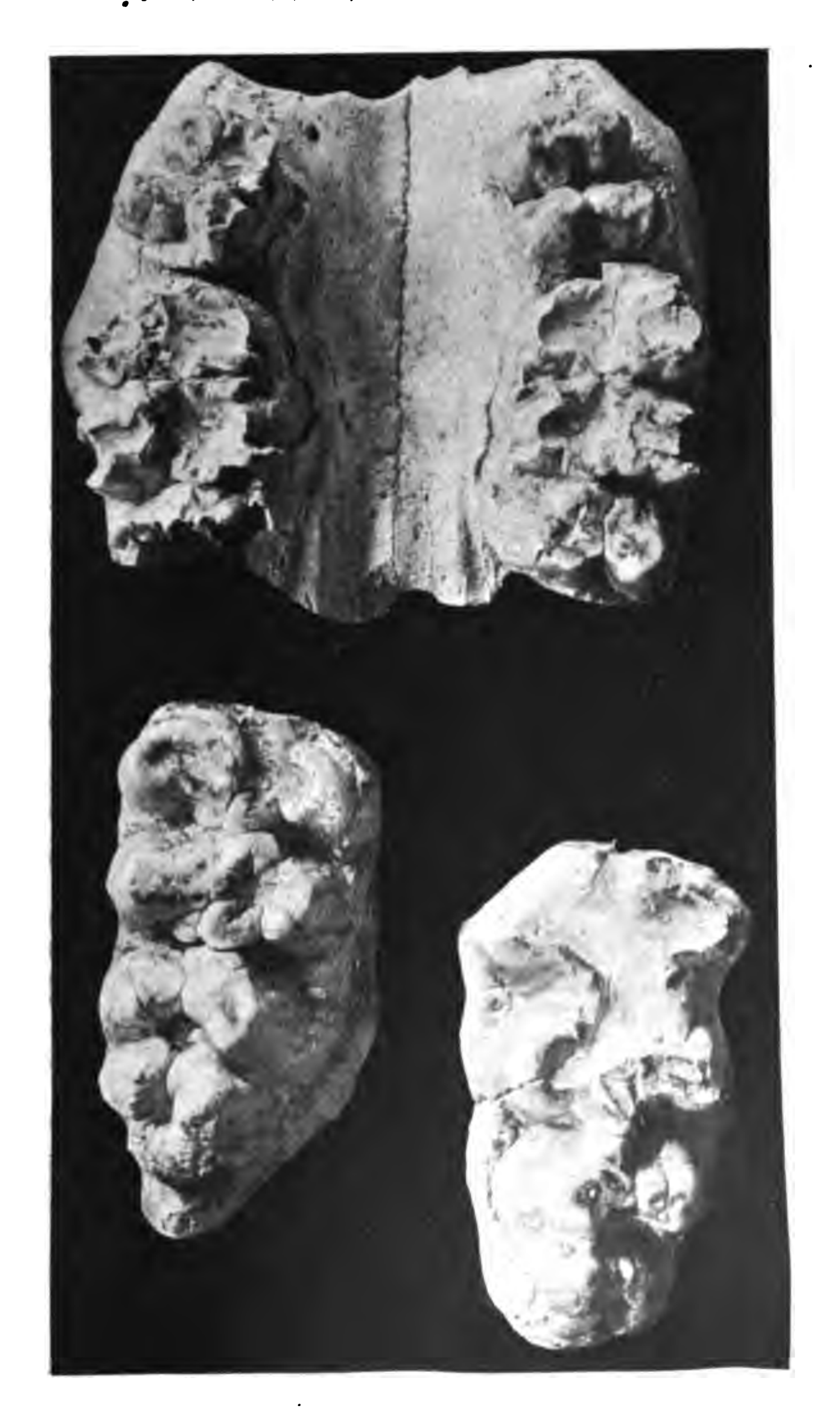


PLATE XXV.

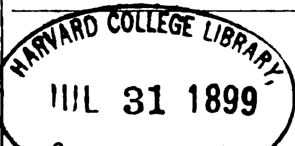
Tetracaulodon Shepardii, Cope.

Upper Figure: Maxillaries with first two molars; Phillips county, Kansas.

Lower Figures: Last upper molars; Phillips county, Kansas.



Vol. VIII. JULY, 1899. No. 3.



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VOL. VIII. JULY, 1899. No. 3.

Notice of Three New Cretaceous Fishes, with Remarks on the Saurodontidae Cope.

Contributions from the Paleontological Laboratory No. 45.

BY ALBAN STEWART.

XIPHACTINUS LEIDY.

Xiphactinus brachygnathus, sp. nov.

In the collection of fossil fishes in the museum of the University of Kansas there is one specimen of *Xiphactinus*, (No. 155), that I have been unable to locate in any of the species described by Professor Cope. It evidently does not belong to the forms which I have referred to *X. audax*,* and does not agree with the descriptions of *X. lestrio* or *X. mudgei*, although our knowledge of these two forms is somewhat vague, owing to the preliminary manner in which they were described by Professor Cope. However, the characters upon which this species is based are such, I am confident, that Professor Cope would have mentioned them if they had occurred in either of the species mentioned. In my paper, (Individual Variation in the genus *Xiphactinus* Leidy),* I figured this specimen and referred it for the time to *X. lestrio*, but was far from being convinced that it belonged to this species.

The premaxilla is somewhat oval in outline and the anterior portion is thickened instead of the central part, as is usually the case in *X. audax*. The posterior border is thin, and is peculiar in hav-

*Kans Univ. Quart. Vol. vii, pp. 115-19, Pl. viii, No. 155.

ing the internal side of bone beveled off to meet it somewhat as in *Ichthyodectes* and *Saurodon*. The alveolar border is elongated and supports three teeth and an empty alveolus for a fourth, all but one of which are small.

The maxilla is especially characterised by the manner in which it unites with the premaxilla; instead of having the abrupt change to the laminar portion in front of the posterior or palatine condyle, found in *X. audax*, the bone is beveled off to a sharp anterior edge, forming a reciprocal surface for the premaxilla. Both of the superior condyles are small, the anterior one is directed well inward, and the two are well separated from each other. In a paper recently published by Professor Hay,* the author was inclined to the opinion that the form of these condyles was of specific value in this genus, giving as an illustration, the differences of these condyles in the forms he refered to, *X. molossus* and *X. thaumas*. In this view I must differ from him. I have examined the maxillæ of a number of specimens of this genus and seldom find two exactly alike; in fact, the variation in this part are remarkably great, as would have been apparent to Professor Hay in a larger series than he had at command. The bone is quite deep at the palatine condyle, and the superior border back of it presents a conspicuous groove, probably for the attachment of the jugal. There are nineteen or twenty teeth on one side and empty alveoli for several more, making a total of about twenty-four. Back of the first six they all seem to be small.

Measurements:

Premaxilla:	length of alveolar border....................	62 mm
"	greatest depth of bone......................	90 "
Maxilla:	length of alveolar border......................	220 "
"	depth at palatine condyle.....................	835 "

The dentary bones are short and deep, presenting thus a very robust appearance. They are much thickened at the symphysis, and slope downward and backward nearly as much as in *X. lowii*. The alveolar border is short, and the teeth are few in number and are remarkable for their large size anteriorly. The arrangement is: three large, two small, one large, and twelve or thirteen medium and small, making a total of nineteen or twenty in all. Many of the posterior alveoli are empty, so that the size of the teeth contained in them has to be estimated. In all probability the number and size of the teeth varies with the individual, as in *X. audax*. The articular portion is very similar to that of the species just mentioned.

*Zool. Bull. Vol. II, No. 1, pp. 34-35, figs. 2-3.

Concerning the exact extent of some of the elements entering into the cotylus there has been some dispute, which this and some of the mandibles of *X. audax* in our collection, will, I think, satisfactorily settle. Cope (Cret. Vert., p. 194) states that the articular is distinct, wedge-shaped, and supports half of the cotylus. Hay (l. c. p. 37) says that the bone called articular by Cope is not short, but is continued forward in a long sword-shaped process, regarded by Cope as being a part of the angular. The first of these Professor Hay designates under the name of "autarticular" and the last, "dermarticular." After examining all of our specimens, I am convinced that Professor Cope was correct, since in several of our best preserved specimens a distinct suture is presented, extending irregularly downward across this sword-shaped process at about the point of "a, art," in Professor Hay's figure of this part (Fig. 5). This suture is often indistinct, and is entirely obliterated in specimens where this part is poorly preserved.

Measurements of mandible:

Length of alveolar border	215 mm
Depth at coronoid process	118 "
Length of symphysis	105 "
Depth of bone just back of symphysis	100 "
Length of bone from cotylus	270 "

There are fragments of several other bones, among which are the ethmoid, prefrontal, palatine, several vertebræ, etc. The ehtmoid is acutely pointed anteriorly, and the posterior suture, uniting it with the frontal, is very dentate. The prefrontals are small, as are also the malleolar portions of the palatines. The external tuberosities of these are less prominent than in *X. audax*.

This specimen was obtained by Professor B. F. Mudge from the Niobrara Cretaceous, four miles north of Gorham, Russell county, Kansas.

In this connection it might be well to make some changes in the family of fishes called *Saurodontidæ* by Professor Cope (Proc. Am. Phil. Soc. Vol. II, 1870, pp. 229-30). I have already divided this family into two distinct groups, (Kans. Univ. Quart., Vol. vii, p. 23), each of which presents characters which I think are sufficient to justify an independent existence, and which should be known as the *Saurodontidæ* and *Ichthyodectidæ*, The first of these should include the genera *Saurodon* and *Saurocephalus* the last, *Xiphactinus*, *Ichthyodectes*, and *Gillicus*. The two names have both been used before in connection with this group of fishes so fortunately the nomenclature will not have to be burdened with new names.

The family *Saurodontidæ*, as characterised by Professor Cope, included the genera *Xiphactinus* (*Portheus*), *Ichthyodectes*, *Erisicthe* (provisionally), *Hypsodon*, *Daptinus*, *Saurodon*, and *Saurocephalus*. *Erisicthe* has since been shown to be a synonym of *Protosphyræna* and removed to a special family, the name *Hypsodon* has been expunged from the group, and *Daptinus* has been shown to be a synonym of *Saurodon*. Since then the genus *Gillicus* has been added by Professor Hay, which leaves the five genera enumerated above.

In 1892, Dr. Crook (Paleontographica, xxxix, p. 129), in an otherwise able paper upon this group of fishes, removes the genus *Saurocephalus* from the family and places it in the *Protosphyrænidæ*, giving for his reasons certain similarities between it and *Protosphyræna* which I have been unable to discover. He also renames the remainder of the group *Ichthyodectidæ*, which had previously been named *Saurodontidæ* by Cope, and *Saurocephalidæ* by Zittel. His reasons for renaming this family are: that the teeth are not like those of Saurians, and that the name *Saurodontidæ* had been already used by Dr. Zittel to designate a family of Ganoid fishes. In a review of Crook's paper Professor Cope (Am. Nat., Vol. xxvi, p. 491), shows wherein he was wrong, and since then the name *Ichthyodectidæ* has not been used by writers on this group of fishes.

Concerning the name *Saurocephalidæ* it can only be said, as Cope's family *Saurodontidæ* was derived from the genus *Saurodon*, the family of Ganoid fishes so designated by Dr. Zittel, will require another name, which has already been given to it by Professor Cope, *Macrosemiidæ*, (Am. Nat. 1889, p. 858.) Thus we see that the name *Saurocephalidæ* will have to be expunged from the nomenclature of this group.

The characters which distinguish the *Saurodontidæ* from the *Ichthyodectidæ* are found in the presence of a predental bone, the differences in the form of the teeth, and the presence of foramina or deep notches below the internal alveolar border in both jaws.

PROTOSPHYRAENA LEIDY.

Protosphyraena gigas sp. nov.

The material upon which this species is based was obtained by myself from the Lisbon Shales, Fort Pierre Cretaceous, one mile east of Lisbon, Logan county, Kansas, in the outcrops just north of the track of the Union Pacific railroad. The specimen consists of the distal portion of a pectoral fin-spine, which was well preserved in a small argillaceous nodule, and is interesting from the fact that

it shows that this genus persisted into the Fort Pierre time. As only the distal end of the spine is preserved, the length of the fin can not be determined, but judging from the width near the middle portion, it must have been larger than *P. gladius* Cope, which makes it probably the largest member of the family *Protosphyrænidæ* S. Woodward.

The spine is made up of parallel rods of bone, closely placed. Near the center of the fragment there are about twenty-five of these and probably more in life, as the posterior border is broken away and the exact number can not be determined. These are broad in the central portion, and become more narrow toward the distal extremity where the spine seems to be regularly rounded on the end. Toward the anterior border the rods become much thicker transversely and the border forms a rather blunt cutting edge, differing from *P. gladius* in this respect where the margin is acute. This border is somewhat irregularly notched, the notches seeming to be more pronounced than in the species just mentioned, and are covered with a coating of enamel-like substance.

Measurements:	*P. gigas.*	*P. gladius.**
Total length of fragment	49 mm	mm
Width near middle	195 "	175 "
Thickness: posterior, near middle	15 "	12 "
" anterior, " "	30 "	

EMPO COPE.

Empo lisbonensis, sp. nov.

This species is established on the left premaxilla of a single individual, found by myself, near the type of the species described above, and is in a fair state of preservation. It indicates a fish of about the size ef *E. nepæolica* Cope.

The premaxilla is much more depressed than in the species just mentioned, but broader across the alveolar portion, thus giving the bone a very robust appearance when seen from below. The anterior extremity is probably not so acutely pointed as in the other species of this genus. None of the teeth are preserved complete, but there are alveolæ present which show that there was an outer row of large and an inner row of small ones. Those of the outer row are reduced in size toward the distal extremity and may entirely disappear before the end is reached, as there are no tooth-scars on this portion. At the posterior end of the internal row there is a very large tooth, back of which is a broad, shallow pit.

*Measurements taken from Cope's description. Cret. Vert., West. p. 244 F.

There is a small portion of the maxilla present with pits for two teeth, which seem to be larger than those on the external row of the premaxilla. Above there is an overhanging lamina of bone on the internal side.

Measurements:

Premaxilla: length to large posterior tooth. . ... 82 mm
" greatest transverse width .... 19 "

Figures of all of these species will be publised in the report upon the Cretaceous Fishes of Kansas now ready for the printer.

Lawrence, Kansas. March 31, 1899.

A New Genus of Fishes from the Niobrara Cretaceous.

Contribution from the Paleontological Laboratory, No. 46.

BY S. W. WILLISTON.

With Plate XXVI.

Leptecodon rectus, gen. et. sp. nov.

Slender and elongate; head elongate, the jaws slender, the anterior extremity in the specimen wanting. The hind end of the mandibles is represented by an impression situated below the posterior end of the skull. Teeth numerous, small, pointed, slender. The orbit is situated posteriorly, is of moderate size and round. Scapular arch strong, the large opercular space in front showing indications of the thin opercular bones. Vertebræ about forty-five in number, elongate, more than three times as long as deep, much constricted in the middle. Pectoral fins small, composed of seven or eight rays. Ventral fin very small, situated about the middle of the vertebral column; caudal fin small, the rays feeble, evidently cartilaginous, the outline indicated on the stone; the shape of the fin is regular apparently, the angles produced. Other fins wanting or not preserved. The side of the body, as preserved, shows three longitudinal rows of large, firmly united scutes, apparently of the same number in each series as the vertebræ. The scutes are in the form of a double trapezium, with the V posterior, the middle raised into a well-marked carina, which runs from the head to the tail. Apparently there are five rows of these scutes on the body. At the front the topmost row is near the middle line, the lateral row has its lower edge over the line of the vertebræ, while the lowest row has the carina just below the pectoral fin. The scutes have a finely roughened appearance, due to minute, rounded and shallow pits. There are no indications of small scutes on the body intermediate between the larger ones.

Length of fish, as preserved	240 mm
Estimated length	250 "
Length of vertebral column	175 "
Greatest width, just back of pectoral fin	27 "
Length of caudal fin, upper lobe	22 "
Length of pectoral fin	7 "
Length of ventral fin	9 "

The specimen lies on the shell of a large Inoceramus, explaining its excellent preservation. Close by are the remains, as seen in the illustration, of several examples of a small fish of unknown affinities, hitherto undescribed. The horizon is the Niobrara Cretaceous of the Smoky Hill River. The specimen was collected by Mr. H. T. Martin in 1895.

The family Hoplopleuridæ, in which this genus must for the present be placed, includes apparently heterogeneous forms, and concerning which there is a diversity of opinion. The definition of the family, as given by Zittel, will not include the present genus, and perhaps some others located in it by that author. He includes the following genera: *Belonorhynchus*, *Saurichthys*, *Saurorhamphus*, *Euryophilus*, *? Palimphemus*, *Pantophilus*, *Eurygnathus*, *Plinthophorus*, *Dercetis*, *Leptotrachelus*, *? Aspidopleurus* and *Pelargorhynchus*, all from the Cretaceous. *Blochius* is placed by him in a separate family, the Blochiidæ.

Belonorhynchus and *Saurichthys* are located by Woodward in another family, the Belonorhynchidæ, widely separated from the Hoplopleuridæ. Lydekker, in his Manual, includes in this family the following genera: *Dercetis* (*Leptotrachelus*), *Aspidopleurus* *Blochius*, *Plinthophorus*, *Pelargorhynchus* and *Saurorhamphus*. *Euryophilus* he locates in the allied family Enchodontidæ.

"The family Hoplopleuridæ was established by Pictet for fishes which were devoid of scales properly so-called, but which are protected on the back and sides by rows of scutes. The head is long and the jaws are provided with pointed teeth of unequal size. The bones of the head are frequently sculptured or granulose. The genera associated in this family by M. Pictet are: *Dercetis* Agassiz. *Saurorhamphus* Heckel; *Leptotrachelus* v. d. Marck; *Plinthophorus* Günther; *Euryophilus* Pictet; *Pelargorhynchus* v. d. Marck. The fished included in the genus *Dercetis* were considered by Agassiz to resemble the sturgeons in the arrangement of the dermal scutes, and were grouped amongst the Ganoids. Heckel held the same opinion with respect to the position of *Saurorhamphus*, and Von der Marck also places the genera *Pelargorhynchus* and *Leptotrachelus*

amongst the Ganoids, but regards *Ischyrocephalus* as a Teleostean. A careful review of the whole of the genera, assisted by additional specimens of *Leptotrachelus* and *Euryophilus* discovered in the chalk of Mount Lebanon, convinced M. Pictet that they formed a group naturally associated, especially by the great analogy afforded by the peculiar arrangement of the series of scutes, and that they formed a family of the Teleosteans, to which he gave the above name."*

Cope long ago described three species and two genera of this group of fishes from Dakota, which seem to have been overlooked by subsequent writers.† Concerning the relationships, he says: "The relationship of the family of Dercetiform fishes has been discussed by various authors, especially by Pictet and Von der Marck. The former regards them as Teleostei; the latter as "Ganoids." As I do not adopt the division signified by the last name, I find Professor Pictet's view nearer to the point. The specimens indicate further that the Dercetidæ belong to the Actinopteri, and probably to the order Hemibranchii. The only alternative is the order Isospondyli, and the characters which separate the two are not clearly shown in the specimens. Distinct bones below the pectoral fins may be interclav'cles, which belong to the Hemibranchii."

The genus *Triænaspis*, from the Niobrara of Dakota, there described, has the dorsal and ventral scuta triradiate, the median branch of the three directed anteriorly, together with numerous band-like scuta. *Ichthyotringa* Co e, from the same locality, has the body covered with small round scales. The third species is *Leptotrachelus longipennis* Cope, in which the dermal scuta consist of median, dorsal, and ventral rows of tripodal form.

From all these as well as other forms the present genus seems amply distinct, though evidently nearest allied to *Aspidopleurus* Pictet and Humbert, from the Lebanon Cretaceous.‡ This genus has not been sufficiently well described to be assured of its more important characters, but the present form evidently differs in the shape of the head, fins, scutes, etc.

The present fish has a curious resemblance to the Pipe Fishes.

*Davis, on the Fossil Fish of the Cretaceous Formations of Scandinavia. Trans. Royal Dubl. Soc., iv, p. 428.
†Bull. U. S. Geol. Surv., Terr. iv, 67.
‡Pictet and Humbert, Nouv. rech. s. les. Poissonis fossiles du Mont Liban, p. 109, pl. x, f. 1; Davis, On the Fossil Fishes of the Chalk of Mount Lebanon, Trans. Royal Soc., iii, pl xxxviii, f. 4.

Notes on the Osteology of Anogmius Polymicrodus Stewart.

Contribution from the Paleontological Laboratory No. 44.

BY ALBAN STEWART.

With Plate XXXI.

This species was first described by myself as *Beryx ? polymicrodus*, from some remains of the tooth-bearing elements collected in western Kansas several years ago, but as this material was poor, no general idea of the anatomy of the animal could be obtained. During the past summer the geological expedition to western Kansas was fortunate enough to secure the remains of several specimens of this species from the Butte Creek region of Logan county, and in addition to this, was loaned an almost complete specimen by Mr. Travis Morse, of Iola, Kansas. From all of the above specimens a very fair idea of the anatomy of this species can be obtained.

The bone called premaxilla in the preliminary description of this form* is evidently not a premaxilla, but some other bone the location of which I have been unable to discover. The premaxilla is rather short with a semi-elliptical band of teeth, below which it is covered with numerous rows of villiform teeth, all of which seem to be directed inward. Above the tooth-band, on the external side, there is a thin wall of bone extending upward which is covered with coarse longitudinal striæ on the posterior portion, while the anterior part is covered with minute tooth-like projections which extend backward for some little distance just over the tooth-band. The internal side of the bone is deeply concave and was doubtless united very loosely with the maxilla, allowing it to be freely moved. The two bones were probably very loosely united with each other anteriorly, if at all.

The maxilla is moderately long and thin transversally toward the

*Kan. Univ. Quar., Vol. VII, p. 195.

posterior extremity. It bears a tooth-band on the lower border which is slightly concave longitudinally and in front where the band is the broadest. Posteriorly the tooth-band gradually contracts in width until the two borders come together at the posterior end. The surface for the premaxilla is directed slightly inward, and in some of the specimens it is slightly roughened for the ligaments binding the two bones together. Just back of this on the superior border there is an elevated articular portion which serves to bind the maxilla to the skull proper. It is rather rough above and does not allow the free motion of the upper jaw found in some of the other families of Physostomous fishes. Just back of this there is a thin crest of bone extending backward over one-half the length of the jaw. Both the external and internal sides of the bone are covered with coarse longitudinal striæ, the intensity of which varies in different individuals.

Measurements:

Maxilla; length of tooth-band	118	mm.
Maxilla; height at posterior extremity	34	"
Premaxilla; length	81	"
Premaxilla; greatest height	375	"

The dentary has a tooth-band above covered with teeth very similar to those on the parts described above. It is nearly flat in front, but soon becomes directed downward internally, giving it a somewhat beveled appearance which may be due to compression, although it seems to occur in all of the specimens examined. The band is broadest near the center and is overhanging externally and in front. The symphysis is composed of two parts; an upper facet which is directed inward and comes in contact with a corresponding facet on the opposite side, and a lower one which is directed forward and enters but little, if any, into the articulation of the two jaws. At the symphysis the bones are shallow, but they soon broaden and become very deep at the coronoid process. There are very coarse ridges and grooves on both the external and internal sides. The articular extends well forward on the external side and is united at the emargination of the dentary by an indistinct suture. The cotylus is supported principally by a thick shelf of bone extending inward from the main portion. It presents a small concave facet which looks slightly forward, back of which the angle is slightly curved and has been described by Cope as resembling a boot with the toe inverted.

Measurements:

Length of mandible from cotylus	204	mm.
Depth at coronoid process	65*	"
Depth at symphysis	17	"
Length of tooth-band	115*	"

The bone originally described as a premaxilla* may be a pterygoid, as it can hardly be a vomer or palatine from the description of these parts as given by Professor Cope. It is slightly curved longitudinally and has a broad tooth-band on one surface which bears denticles slightly larger than those on the parts described above. On the opposite surface from the tooth-band there is a ridge extending its full length which is overhanging on one side, thus forming a groove which is evidently for the reception of some other bone.

Measurements:

Length of tooth-band	69	mm.
Greatest width of tooth-band	17	"

There are two other bones which are covered with small pits and somewhat resemble those found on the tooth-bearing elements described above, although it is likely that these bones never bore teeth. One of these is a cardiform bone, probably a pharyngeal. The pitted surface is slightly depressed in the middle and the sides slope sharply toward the edges. The other element is not so thick as the one just mentioned; it has a broad band of these pits on one side and a median ridge on the other, somewhat similar to that found on the supposed pterygoid described above. At one of the ends there is a roughened articular surface. There is another long and slender element that bears a certain resemblance to the palatine(?) bone of *Stratodus apicalis* Cope, which is no doubt the same bone described as a palatine by Professor Cope.† It is broader at one end than at the other. The lower(?) surface is covered with pits similar to those described above, but there are no teeth present in any of the specimens that I have examined. The upper surface is somewhat striated at the anterior(?) extremity. The ceratohyal is broad and thin, concave at the posterior end and somewhat irregular in outline at the other, where there are two surfaces for the hypo- and uro-hyals respectively. The bone seems to be striated, especially so toward the extremities. Its length is 98 mm.

*l. c., p. 195.
†Proc. Am. Phil. Soc., 1879, p. 179.

The quadrate is fan-shaped, and thin anteriorly. The condyle is very convex and has a superficial resemblance to the distal end of the mammalian femur. Extending upward from this along the posterior border externally there is a prominent ridge which continues upward to the superior border. The groove for the symplectic seems to be very small.

One specimen shows the top of the skull with most of the bones in place. The frontals are long, extending backward as far as the pterotics externally. They meet in the median line by a suture which is probably dentate, although this can not be determined with certainty. On each side there is a small postorbital process. The bones are beautifully sculptured above with coarse sulci which radiate from near the centers of each, internal to the postorbital processes. The parietals are small, meet each other in the median line, and are covered with markings very similar to those on the frontals. The supraoccipital is in a poor state of preservation and probably entered but little into the formation of the upper part of the skull. It seems to have been projected backward for quite a distance and was depressed, as was the rest of the top of the skull. The epiotics and pterotics seem to be united on the side of the skull which is preserved. The pterotics form prominent angles of the skull, while the epiotic processes are not so prominent. The two are covered with small pits and tubercles of bone. Just back of the skull there are portions of two other bones which may be portions of the hyomandibular and supratemporal. The first of these presents two articular surfaces, one of which extends outward from the rest of the bone, the two being separated by a wide space, somewhat similar to that found in the hyomandibular of *Empo.* The other is an irregularly shaped bone and has an articular surface on the side next to the skull There are numerous other small bones, sculptured in a manner similar to the bones of the top of the skull. Three of these are joined together in a chain and from their position would seem to form a part of the rim of the orbital cavity. The remainder of these bones are scattered along near the top of the skull and indicate that this part might have been covered with dermal plates. The orbital cavity is large and the orbit is surrounded by a thin sclerotic ring. Just in front of the orbital cavity, and separated from it by the chain of bones mentioned above, there is a bone which occupies about the position of the ethmoid. It seems to be rather thin and crushed down on the opposite side so that its remaining characters can not be made out.

The opercular bones are thin and scale-like, and are all in place. They are covered with fine striæ and are so thin at the edges that the different directions that these striæ take are the only means of locating the boundary lines between some of the different elements. The preoperculum is small, narrow above and extended well forward below. The operculum is large and is extended for some distance above its articulation with the hyomandibular. The inter- and sub-operculars extend backward as far as the operculum.

In one specimen there are seventy-two vertebræ exposed to view, and there are probably eight or ten more hidden by the opercular bones just back of the skull, making in all about eighty vertebræ in the complete column. The centræ are all rather short and do not present the lateral grooves found in the *Saurodontidæ* and *Ichthyodectidæ*, but are striated and somewhat resemble the vertebræ of the genus *Pachyrhizodus* Agassiz in this respect. Just in front of the caudal fin the vertebræ are crowded together, and those supporting the fin are very much so. The last vertebra is succeeded by a fan-shaped expansion or urostyle, which presents a well-marked ridge on the side exposed. The neural arches fit into pits at their bases and in the caudal region they have lamina of bone projecting down the sides forming yoke-like articulations with the centræ. The arches are expanded at their bases and are largest in the anterior region, where they are directed backward but slightly, while in the region of the fiftieth posterior vertebra the arches are very slender and directed strongly backward. The manner of attachment of the hæmapophyses can not be made out certainty, although they were probably inserted in pits as are the neurapophyses. The ribs are long and slender and slightly expanded at the proximal extremities. They seem to be inserted in pits on the sides of the centræ. The caudal fin is homeocercal and is composed of numerous rays which unite with the centræ by means of the yoke-like articulations mentioned above. Toward the distal extremity the rays split up into many thread-like filaments, which makes this portion very difficult to collect in a perfect condition. The body is covered with medium-sized elliptical cycloid scales. The total length of this fish was about 1.82 m. There is not enough of the fin-remains present to determine their character.

Lawrence, Kansas, May 15, 1899.

New Fossils from the Kansas Coal Measures.

Contribution from the Paleontological Laboratory No. 45.

BY J. W. BEEDE.

With Plates XXXII, XXXIII.

Ceriocrinus monticulatus. n. sp. Plate XXXII, Fig. 2.

Calyx basin-shaped, moderately deep, concave at base, arms moderately stout, number not known, pinnules moderately long. Infrabasals not known, but small and nearly or quite covered by the stem. Basals large, hexagonal, or perhaps pentagonal, convex, curved inward at the base, about as high as wide, upper lateral edges sometimes a little unequal on account of the unequal radials, which makes some of the upper and lower lateral edges unequal also. Radials somewhat unequal in size, pentagonal, the upper edges beveled, about twice as wide as high, upper surface faceted. Costals five, pentagonal in outline, somewhat produced exteriorly but not spinous, twice as wide as high, with single facet below to meet the radial and two above for the articulation of the distichals. Distichals two to each costal, quadrangular to pentagonal according to the number of arms supported, apparently faceted above and below. Those supporting two arms are very similar in shape to the costals. There are often one or two palmers, before the postpalmers begin, at the base of the arms. Arms long, rather stout, number not known, but somewhere from fourteen to eighteen, ten in view above three radials. They are made up of two series of short, stout, interlocking, cuneiform plates, each bearing a single, long pinnule. Pinnules composed of at least eight long slender joints, slightly grooved in the inner side. Along each side of the groove is a row of closely set nodes to which secondary pinnules were apparently attached. The entire surface of the cup and arms is covered with monticules and fine granulations.

Measurements:

	Height.	Width.	
Basals	10 mm.	10 mm.	
Radials	6 "	11 "	
Costals	5 "	10 "	
Distichals	5 "	7 "	
Arms	53 "	¾ "	
Pinnules	11 "	½ "	about.

Taken from the shales above the Osage coal at the Capital Coal mine near Topeka, Kansas.

There is a little doubt about this being a true *Ceriocrinus* on account of the nature of the arms and the fact that all the specimen is not exposed. The nature of the infrabasals can not be made out. There are three radials exposed, the central one supporting two arms, and the other two four arms each. Until more of its characters are known it is referred provisionally to this genus.*

Eriocrinus megalobrachius, n. sp. Plate XXXII, Figs. 1a, 1b

Calyx basin-shaped, base quite concave, ornamented by very coarse granulations which are sometimes arranged in wavy rows. Infrabasals unknown, covered by the small column. Basals large, convex, the lower portion curved upward to meet the infrabasals forming a deep cavity in the base of the cup, the inner, or lower, end of the basals being in about the same horizontal plane as the upper end and hence forming the most of the base of the calyx and leaving the infrabasals almost entirely within the calyx; higher than wide, all equal, and apparently pentagonal, the lower side (or sides, if two) short, superior and interior lateral edges nearly equal and the apical angles extending upward between the radials to fully half the height of the latter. Radials five, equal, pentagonal, twice as wide as high, massive, convex, considerably beveled at the upper edge; upper surface deeply faceted for the reception of the costals, raised portions of the facet crenulated. Costals five, massive, stoutly spine-like, pentagonal in outline, the lower inner surface faceted to meet the radials, upper surface faceted (except the portion protruding in the form of a stout spine) to support the two large arms. Distichals either one or two to each arm, more commonly two in our specimen, the lowermost quadrangular in outline, massive, a little more than twice as wide as high; the second distichals very variable, from four to six times as broad as high. There are ten arms which are very broad and stout, each made up of two series of wedge-shaped, interlocking

*Since this was written another specimen has been seen with an anal plate. The two seem to be the same species or, at least, nearly related.

plates, which are twice as long as high in the lower portion of the arms and each supporting a single pinnule. The pinnules are not well preserved, but are stout, composed of rather large, square plates near their junction with the arms, while further away they assume a cylindrical form. When not worn the entire specimen is covered with coarse granulations which are usually a little prolonged.

Measurements:	Height.	Width.	Length (beyond calyx).
Basals	11 mm.	10 mm.	
Radials	8 "	16 "	
Costals	5 "	15 "	9 mm.
1. Distichals	1 to 2 "	8 "	
2. Distichals	2 "	4 "	
Average lower arm plate	2 "	4 "	

Upper Coal Measures, from Topeka, Kansas, from the horizon of the Osage coal.

This species agrees in many respects with *Ceriocrinus craigii* (Worthen) W. and S., and *C. hemisphericus* (Shumard) W. and S., but each of these possess an anal plate, while the specimen in hand, though preserved in good condition, shows no indication of such a plate. It is placed provisionally with the genus *Erisocrinus* as the nature of the infrabasals can not be made out from this specimen. It may prove to belong to *Stemmatocrinus* when the nature of these are determined. In discussing these two genera Wachsmuth and Springer make the following observation: "We also observe a difference in the construction of the arms, which in the former (*Stemmatocrinus*) are composed of a double series of interlocking plates, while in the two species of *Erisocrinus*, in which the arms have been found, they are composed of single transverse plates. Both species, however, are from the Burlington limestone, and are very small, and it is extremely probable, from analogy with contemporaries, that the arms in the species from the Coal Measures, where the genus flourished more abundantly, were, as in *Stemmatocrinus*, composed of interlocking pieces, and that the Burlington species represent the young form. This would make the difference in the underbasals the only visible distinction."* *E. typus* and the Topeka, specimen here described exactly fulfil this prediction, if it be a true *Erisocrinus*, as it probably is.

*Revision Palæocrinoidea I, p. 140.

Oligoporus? minutus, n. sp. Plate XXXII, Fig 3.

Small, depressed globular, melenitic ridges not very distinct. There are four columns of pores, each column consisting of two rows in each ambulacral area, each row consisting of two rows of pores, the rows of each column closely arranged. Each series is apparently separated by a row or two of imperforate plates at the ambitus. Both series are in contact at the apex? and near the mouth?. Number of columns of interambulacral plates unknown, but apparently about three. The ambulacral area is very wide and the two series are widely separated at the ambitus. Some of the elevations on the interambulacral plates seem to be pierced by a single pore or sometimes two. Indistinct elevations seem to be present in three columns, one of large and two of small size.

Measurements:

Diameter of specimen	23	mm.
Maximum diameter of ambulacral area	6	"
Maximum diameter of each series	2	"
Maximum diameter of interambulacral area	7	"
Pores in vertical rows	⅔	"
Pores distant in same series	1½	"
Pores in single pair	¼	"

The specimen is badly worn and somewhat compressed; the surface markings are almost entirely removed. It agrees to some extent with *Oligoporus*, but the ambulacra are divided into two series with, apparently, two columns of imperforate plates between them. However, this is not unquestionably shown by this specimen. It will in all probability be found to belong to an entirely different genus. It is referred to *Oligoporus* for convenience, until better material can be secured. It does not seem to present the appearance of any other Carboniferous genus.

It was collected from the Deer Creek limestone northeast of Topeka, Kansas.

Posidonomya? recurva, n. sp. Plate XXXII, Fig. 6.

Shell of medium size, lenticular, oblique, and thin. The hinge line is nearly straight, about two-thirds the length of the shell. The beak is moderately prominent, recurved, projecting very slightly beyond the hinge. The greatest convexity is on the upper half of the shell and constitutes the umbonal swell which is moderately prominent and curved backward, making the shell oblique. The surface is marked by concentric undulations of growth and fine, closely set, concentric striæ.

Measurements: Height, 23 mm.; length, 23 mm.; convexity of valve about 4 mm.

Taken from the rock at the dam at Lawrence, Kansas.

A specimen from the dam, at Lawrence, and shown in Figs. 6b and 6c, Plate XXXII, is probably of the same species, though it has a somewhat different appearance and outline. It shows the beak projecting beyond the hinge and the cast of the interior shows the beak to have been hollow beyond the hinge. The cast figured is of both valves in place, one of which is slightly crushed. It may be a distinct species, though as it is from the same horizon it is probable that the difference is individual rather than specific.

The character of the hinge and the internal markings are too poorly shown in our specimens to permit of the accurate location of the species. It resembles very much in appearance species of the genus *Posidonomya*, to which it is provisionally referred, and with which it agrees in its surface markings and in having a very thin shell. It also agrees very well in these respects with *Paracyclas*, but that genus is not at present known from the Carboniferous.

Posidonomya? pertenuis, n. sp. Plate XXXII, Fig. 5.

Shell a little larger than the previous and less oblique. Transversely ovate in outline, very thin, quite compressed. The hinge line is nearly straight and about equaling half the length of the shell. The posterior? margin is somewhat truncate and nearly straight; anterior extention of the hinge longer than the posterior, rather flat, not separated from the shell by well defined depression. The front and ventral margins regularly rounded. The shell is compressed, probably most convex near the middle, beak obtuse, not very prominent, protruding above the hinge line. The surface is marked by concentric undulations of growth and fine, close, concentric striæ.

Measurements: Height, 40 mm.; length, 36 mm.; convexity of single valve, 4 or 5 mm.

The type specimen was taken from near the dam at Lawrence, and others have been taken since from the same stratum at Cameron's Bluff, three miles up the river.

This species belongs to the same genus as the preceding. It has some resemblance to the figure of Keyes'*, which he refers to *Placunopsis carbonaria*, though it is very difficult to see why it should be referred to that genus or species; his species may be the same as the one here described.

*Geol. Surv. Mo., v, p. 108, pl. xliii, f. 9.

Myalina? exasperata, n. sp. Plate XXXII, Fig. 4.

Shell cuneate-ovate in outline, beaks pointed, terminal, shell very thin, apparently composed of a single layer, compressed, valves nearly or quite equal. The anterior? margin nearly straight above, and merging into the narrowly rounded ventral region; the posterior? region similar to the anterior, but more oblique. The surface is granular and marked by indistinct, rather broad, concentric striæ.

Measurements: Height, 43 mm.; length, 28 mm.; convexity, 3 mm.; length of hinge about 29 mm.

Several specimens of this shell have been collected from the coal mines west of Topeka, Kansas.

This shell has been known for several years from the above locality, though the extreme thinness of the shell and the softness of the shale in which it occurs makes it almost impossible to collect good specimens of it.

The hinge of this shell is not sufficiently well shown to permit of its proper classification. It is left in *Myalina* for the present, for want of better information concerning its beak and muscular impressions. The extreme thinness of the shell makes it very probable that it does not belong to that genus.

Somphospongia, n. gen.

A globular to mushroom-shaped calcisponge, attaining a large size, and generally possessing a somewhat spherical-shaped cloaca near the base, the inhalent and exhalent canals too similar to be distinguished, all very irregular and crooked, distributed over the entire surface and moderately large; there is a thick dermal layer covering the entire animal, which was free, apparently resting with the base in the mud in the adult stage.

Somphospongia multiformis, n. sp. Plate XXXIII, Figs. 1 to 10.

Small to very large sponge varying in form from globular to mushroom-shaped, free, and gregarious. Connecting with the cloaca there is an irregular, branching, canal system which communicates with the exterior over the whole surface, though in the larger specimens they seem to be smaller and probably nearly useless at the base. These canals are very irregular in shape, and, when viewed on the surface, appear to be labyrinthine; they become smaller as they proceed inward toward the cloaca and less numerous. When unweathered the entire sponge is covered with a moderately thick dermal layer, the folds of which form the walls of the canals. There is no sign of attachment in any of our specimens,

and the young ones seem to have been rolled about until they had gained some considerable size as the pores are about equally developed all over them and they are globular in form. Wherever these animals were very abundant, as is generally the case wherever they are found, they soon come in contact with each other and form a solid mass, sometimes appearing to coalesce, but generally in breaking they part along the line of contact and neither specimen seems to be ruptured. As yet spicules have not been positively made out. There seem to be no siliceous spicules and several thin sections have failed to show any calcareous ones. The absence of siliceous spicules and chert in the specimens, and the absence of chert in the rock, makes it practically certain that they are calcareous sponges, unless they are horny, and the fact that the limestone is mostly made up of them practically precludes that idea. There is, however, on weathered specimens, where the dermal layer has been removed, a peculiar, more or less haphazard arrangement of pits surrounded by elevations which may be caused by an internal calcareous skeleton, composed of fused spicules. One of the more regular of these surfaces is figured on Plate XXXIII, Fig. 10. The different individuals vary from half an inch to a foot or more in diameter, but seldom are more than six inches high.

They are found in abundance in the northwestern part of Atchison, western Doniphan and eastern Brown counties. It is not uncommon to find them making up a stratum of limestone six inches thick. They seem to be confined to a single, narrow horizon in the Burlingame shales. The cloaca is generally filled with limestone which, except at the center, is arranged in concentric layers as it was filtered in, giving the cloaca and the parts immediately surrounding it much the appearance of a concretion.

This sponge evidently belongs to the *Pharetrones*, and appears most closely related to *Cyronella* and *Stellispongia*. It differs from the former in not having the cloaca funnel-shaped and the fact that the cloaca does not terminate below in vertical branching tubes any more than it does above, and possesses no distinct exhalent aperture. It is much more closely related to the latter, but is simple, and appears quite different in its spicules, while the cloaca is confined to the base. It may be an antecedent of that genus.

The shales in which they are found abound elsewhere in typical marine Coal Measures fossils and are immediately associated with *Lingula*, *Productus* and a few pelecypods and gastropods. Associated with them also were a large quantity of dipnoan fish re-

mains (*Sagenodus*) which Dr. Williston has described elsewhere in this number. The limestone in which the fish are found is almost entirely made up of sponges. It is from a thin limestone about six inches in thickness in a ravine three miles northeast of Robinson, Kansas, that these specimens and the fish were taken.

New and Little Known Pelecypods from the Coal Measures.

Contribution from the Paleontological Laboratory No. 46.

BY J. W. BEEDE AND AUSTIN F. ROGERS.

With Plate XXXIV.

Solenomya parallela, n. sp. Plate XXXIV, Fig. 1.

Shell large, moderately convex, elongate-subquadrate in outline; anterior margin broadly rounded to nearly truncate, meeting the hinge at a little more than a right angle, dorsal and ventral margins straight, nearly parallel, postero-dorsal margin sloping obliquely downward, meeting the rounded posterior margin at an obtuse angle. Beaks depressed, incurved, situated about one-fourth the distance from the posterior to the anterior end of the shell. The greatest convexity is at the umbo. The shell gaping a little wider anteriorly than behind. The surface is marked by flat radiating plications, which become obsolete at either end of the shell, the whole surface of which is apparently covered with radiating striæ parallel to the plications. Neither the plications nor the striæ radiate directly from the beak, but from a point above the beak and a trifle in front of it. These are crossed by fine obscure lines of growth. The anterior and posterior adductors are prominent; the posterior one is triangular, located between the beak and the posterior margin, along its anterior side and extending above it is a ridge caused by the thickening of the shell, which produces a slight, oblique furrow in the cast. The anterior scar is located on the upper side of the shell near the anterior angle. The pallial line is indistinct, parallel to the ventral margin curving backward to meet the anterior adductor scar.

Measurements: Length, 53 mm.; height, 18 mm.; convexity of single valve about 5 mm.

Specimens of this species have been collected from Kansas City and Lawrence.

Solenomya trapezoides Meek*. Plate XXXIV, Figs. 2a, 2b

Shell large, subelliptical in outline, length from two to two and one-half times the height, convex, open at both ends. Ventral margin slightly convex, curving abruptly upward on the posterior extremity and more gently on the anterior, posterior side obliquely truncated above; hinge straight in front of the beaks which are depressed, approximate, located about one-fourth the length of the shell from the posterior extremity. Surface marked by rather obscure concentric undulations of growth, crossed by faint radiating striæ which seem to radiate from the beak. Posterior adductor scar moderately prominent, more or less irregularly subcircular; the ridge in front of the scar is broad and its outline is rather indistinct, nearly perpendicular to the hinge, curving backward below; anterior scar indistinct, somewhat subcircular; pallial line extending backward and downward from the lower side of the posterior scar, then curving abruptly forward parallel to the ventral margin to the middle of the shell, where it becomes too indistinct to trace in our specimens.

Measurements of a specimen a little below the average size and a larger specimen: Length, 56, 76 mm.; height, 24, 33 mm.; convexity, 15, 25 mm.; respectively.

Found in the rocks near the junction of the Upper and Lower Coal Measures, Westport, Mo., and Porterville, Kansas.

There can be but little doubt but that this shell is specifically distinct from *S. soleniformis* Cox. It is abundant at Westport, and we also have a specimen from Peoria county, Illinois. The only manner in which the specimen at hand seems to differ from the species to which it is referred is in the possession of faint radiating striæ, which do not seem to appear on specimens that are worn.

Nucula pulchella n. sp. Plate XXXIV, Figs. 5a, 5b, 5c.

Shell very small, subtrigonal in outline, ventricose; anterior border straight, rounding abruptly to the ventral margin which is rounded, posterior abruptly truncated nearly at a right angle with the ventral margin. Beaks prominent, incurved, situated nearly at the posterior end of the shell, lunule not well defined. The greatest convexity is at the umbo. The surface is ornamented by fine, elevated, concentric striæ and undulations of growth.

Measurements: Length, 4½ mm.; height, 3½ mm.; convexity, 3 mm.

Found at Cameron's Bluff, near Lawrence, Kansas. Type in Mr. Rogers' collection.

**Solenomya* sp. Meek and Worthen, Geol. Surv. Ill., v, pl. xxvii, f. 1a-b, 1873.
**Solenomya trapezoides* Meek, Amer. Jour. Sci., (3) vii, pp. 58?-583, 1874.

This shell is more closely related to *N. illinoiensis* Worthen, from the St. Louis limestone, than to any other species, perhaps, but differs from that species in having the angles of the outline much more sharp, in being smaller, and very distinctly concentrically striated. With a strong lens these striæ can be seen to be occasionally minutely crenulated. The furrows are twice or more as wide as the striæ. Several specimens of this interesting little shell have been secured from Cameron's Bluff in almost perfect preservation.

Yoldia glabra, n. sp. Plate XXXIV, Figs. 4a, 4b.

Shell medium size for this genus, truncate-subelliptical in outline, nearly flat, greatest convexity at the umbo, sloping gently in all directions from the central portion of the valve; anterior dorsal outline nearly straight, sloping gently, and broadly rounded into the anterior ventral margin, which forms an elliptical curve to the posterior end, where it is somewhat truncate, meeting the hinge at an obtuse angle. Hinge-line back of the beak nearly straight. Beak depressed, nearly central. Surface nearly smooth, with traces of obscure, distant, concentric striæ parallel to the ventral outline; lines of growth visible on the postero-dorsal region.

Measurements: Length, 14½ mm.; height, 7 mm.; convexity of single valve, 1½ mm.

Cameron's Bluff, near Lawrence, Kansas. Type specimen in Mr. Rogers' collection.

This shell differs from *Y. levistriata* M. and W., from the St. Louis group, in having its posterior border truncated, striæ distant rather than closely arranged, and in being much less convex. It differs from *Y. subscitula?* Meek (or *Y. propinqua* Meek, if it is distinct), in being more depressed and the posterior (anterior) end much more broadly rounded. Otherwise it is very similar to it.

Monopteria? subalata, n. sp. Plate XXXIV, Figs. 3a, 3b.

Shell moderately small, subcrescentic in outline, gibbous, a little longer than high; valves subequal, beak prominent, slightly projecting, somewhat inflated, situated about one-fifth the length of the shell from the anterior margin, which is truncated on account of the lunule which is formed by the turning in of the shell. The anterior margin is convex below. Ventral margin broadly rounded to the postero-ventral extremity where it is abruptly rounded to meet the concave posterior. Hinge short and straight; posterior ear but slightly developed; umbonal ridge prominent, somewhat sickle-shaped, sloping abruptly posteriorly forming a concavity,

broadly convex anteriorly. Surface marked by moderately distinct lines of growth.

Measurements: Length, 16 mm.; height, 14 mm.; convexity of single valve, 4 mm.

Lawrence oolite, Lawrence, and also from the horizon of the Osage Coal at Topeka, Kansas.

The generic position of this shell is uncertain. It is very similar to White's *Anthracopteris polita*, but seems specifically distinct from it. The only difference between our shell and the true *Monopteria* is that the posterior ear is less developed than in that genus. The beak, and especially the lunule, are precisely as in *Monopteria*, as well as the general expression of the shell. The internal characters are not known. It is closely allied to *Monopteria* sp. Keyes, but its posterior ear is less developed and the umbonal ridge much more curved, and the whole shell more slender than is represented in his figure. Until the internal characters can be found out we place it in the genus *Monopteria* provisionally.

Note on the Distribution of the Cheyenne Sandstone.

BY CHARLES S. PROSSER.

In the writer's report on the "Comanche Series of Kansas" he referred a yellowish, quartzitic sandstone outcropping near the base of Arilla hill, in the southern part of Comanche county, to be Cheyenne sandstone.[1] The rocks in the draw studied by the author were partly covered, and later studies of better exposures by Messrs. Vaughn and Gould and Prof. Ward have shown that too great a thickness was assigned to this stratum, and that it does not rest on the top of the Red-beds, but is separated from them by from three to ten feet of their black shales.[2] It appears probable that there is some variation in the thickness of these strata as exposed in the different draws at the foot of Arilla hill.

This yellowish to brownish sandstone belongs in the lower part of the Kiowa formation, as stated by Prof. Ward,[3] instead of representing the Cheyenne sandstone. Since Vol. II of the University Geological Survey of Kansas was published, Prof. Cragin has studied some of the fossils from this sandstone and has written me as follows:

"There are only two of the fossils which I am willing to take the chances of naming. These are *Avicula belviderensis* and *Cucullæa recedens* with little doubt. Some of the others, perhaps, are *Tapes belviderensis* and *Cardium* sp., and possibly *Cyprimeria*, in small phase, and one or two other genera are represented; but I feel confident of only two.

"You will remember that I have mentioned lenses of sandstone as occurring in the Kiowa shales and carrying regular Kiowa fossils, and these casts and the attached rock-samples have the ap-

1 Univ. Geol. Sur. of Kan., vol. ii, pp. 143-44.

2 Mr. Vaughn's section gives above the Red-beds five feet of yellowish clays, followed by ten feet of black paper shales, capped by one foot of brown sandstone, above which are again black shales. (Am. Jour. Sci., IV. series, vol. iv, 1897, p 46.) Prof. Ward wrote me that the sandstone was not over ten feet in thickness, below which were three or four feet of black paper shales which lie directly on the Red beds. Mr. Gould's section for the same strata is two to six feet of yellowish clay on the Red-beds, then six to ten feet of black shales with one to two feet of sandstone containing fossils.

3 Science, N. S,, vol. vi, Nov. 26, 1897, p. 815.

pearance of having come from such sandstone, which is, perhaps, more largely developed in the Arilla hill than anywhere in Kiowa county. The Kiowa lenses are usually rather hard and highly ferruginous, like the material in which these casts are preserved."[1]

In the western part of Clark county is a yellowish to grayish-white sandstone, named by Prof. Cragin the Big Basin sandstone,[2] and referred to him to the top of the Cimarron series. From the writer's studies in the Big Basin region he was inclined to consider it as representing the Cheyenne sandstone,[3] but sections described by Prof. Cragin and Mr. Gould seem to show that the former correlation is the correct one. Prof. Cragin writes "that there are on Two-mile, a west side branch of Big Sandy creek, Red-beds higher than the bed referred to as Big Basin sandstone in my article 'Observations on the Cimarron series',[4] and that there are in central Oklahoma beds which seem to be considerably higher yet."[5] The correlation of this sandstone with the Red-beds is accepted by Prof. Ward, who regards it as their "upper indurated portion."[6]

1 Letter of December 15, 1897.
2 Colorado College Studies, vol. vi, p. 46.
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Leptecodon rectus Will.

Two-thirds natural size.

PLATE XXXI.

Skull of *Anogmius polymicrodus* Stewart, one-half natural size, *Den.*, Dentary; *Art.*, Articular; *Mx.*, Maxilla; *Pmx.*, Premaxilla; *Q.*, Quadrate; *Ch.*, Ceratohyal; *Sc.*, Sclerotic ring; *a, a, a, a,* Dermal plates; *Op.*, Operculum; *Pop.*, Preoperculum; *Iop.*, Interoperculum; *Sop.*, sub-operculum; *Or.*, supposed orbital bones.

PLATE XXXII.

1. *Erisocrinus megalobrachius.*

    1a. View of base of calyx of type.

    1b. Side view of type.

2. *Ceriocrinus? monticulatus.* Side view of type.

3. *Oligoporus? minutus.* Top view of type showing the arrangement of the ambulacra.

4. *Myalina? exasperata.* Left? view of type.

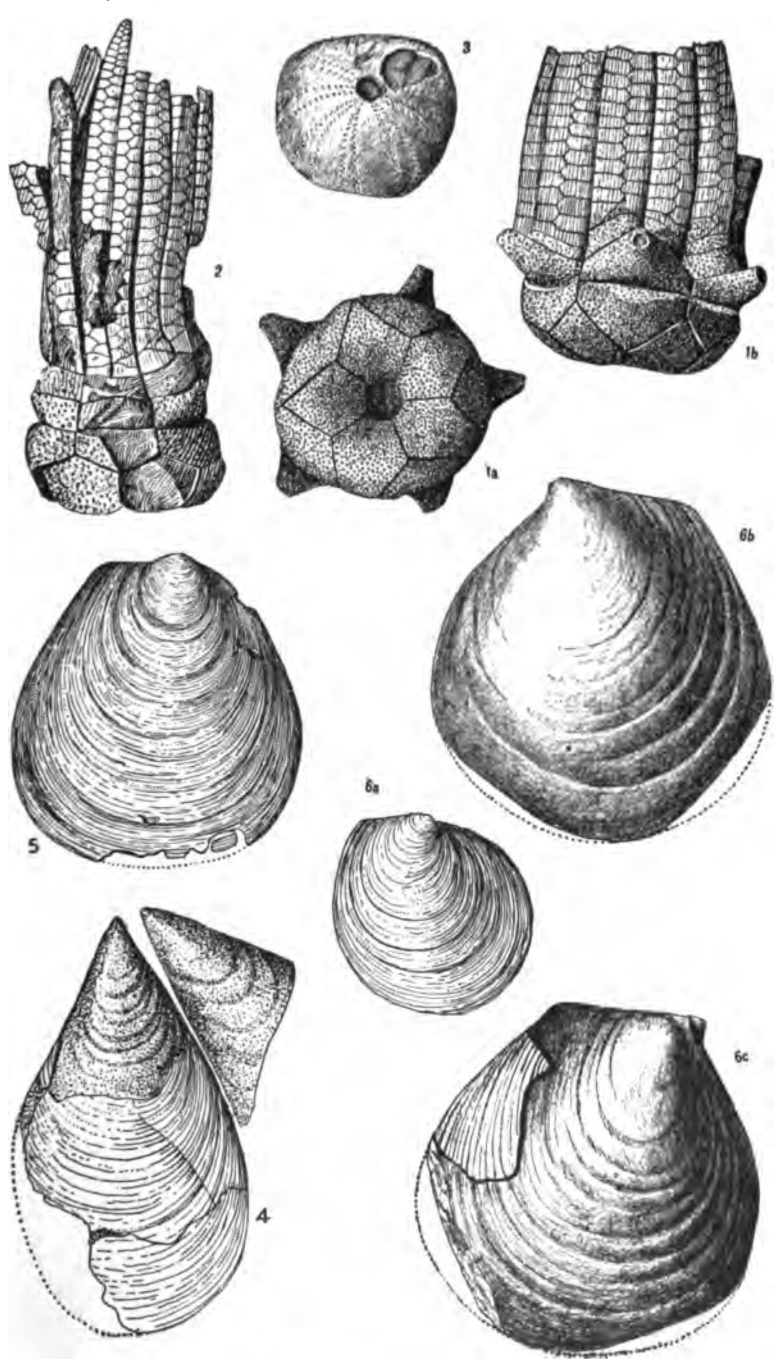
5. *Posidonomya? pertenuis.* Left? valve of type.

6. *Posidonomya? recurva.*

    6a. Left? valve of type.

    6b. Right? valve of another specimen, a cast.

    6c. Left? valve of the above with a portion of the shell left on one side, which shows the surface markings. The beak is somewhat crushed and twisted so that it does not appear to extend above the hinge.



Syd. Prentice, del.

PLATE XXXIII.

Somphospongia multiformis.

1–4. Figures to illustrate the outlines of smaller specimens. Less than natural size.

5. Photograph of the top of another specimen showing the canals. Less than natural size.

6. Drawing to illustrate the thickness of the dermal layer. Magnified.

7. Outline of larger specimen showing mushroom-form. One-half natural size.

8. Tracing of a section through the top of one of the sponges showing the arrangement of the canals, which are stippled. The unstippled portion is the body of the sponge. Reduced one-half.

9. Semidiagrammatic section through the cloaca of a small individual showing the canals, which are stippled, and the semiconcretionary nature of the outer part of it.

10. Portion of the surface of a weathered specimen showing what appears to be the body skeleton of the sponge. Magnified.

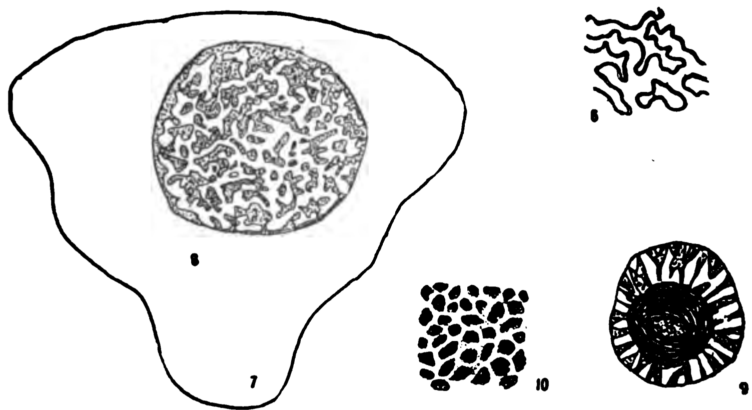


PLATE XXXIV.

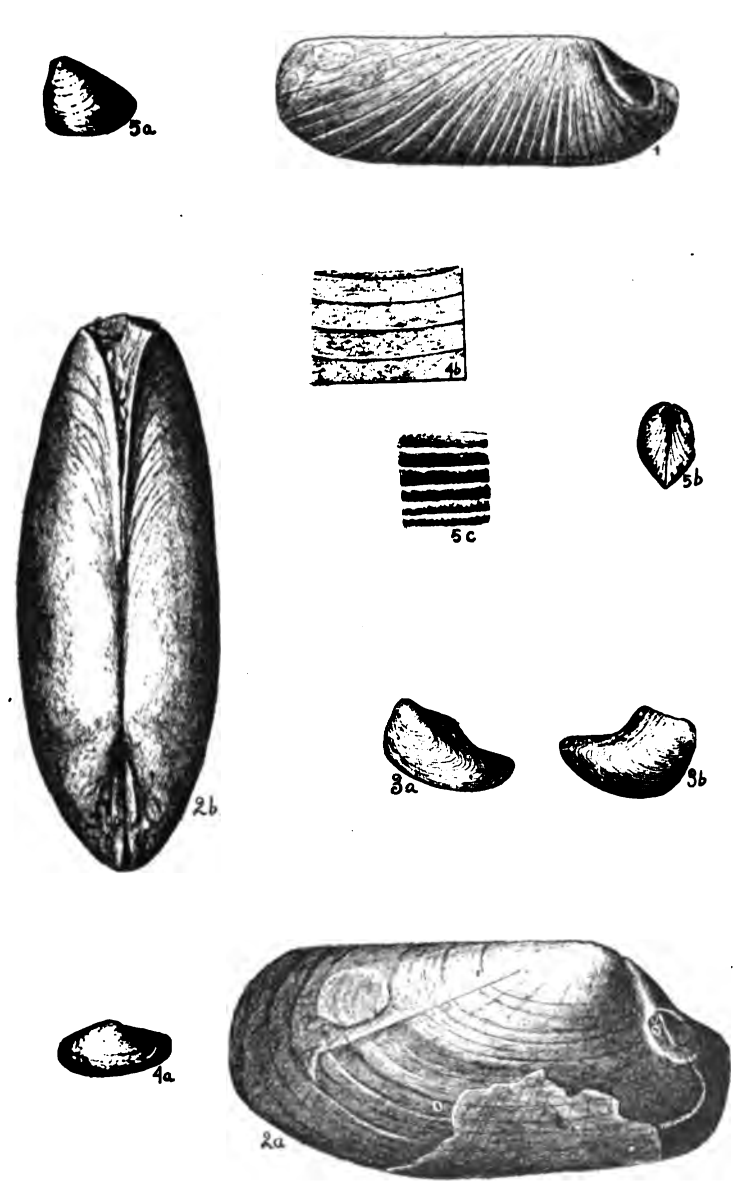
1. *Solenomya parallela*· Side view of type, which is a cast, showing the adductor impressions, impressions of the shell plications and the indication of the pallial line.

2. *Solenomya trapezoides.*
   - 2a. Side view of left valve. The anterior adductor scar is somewhat exaggerated as is also the pallial line in front (to the left) of the fragment of shell which remains on the cast. The shell has traces of fine radiating striæ, which are suggested in the figure. They appear to radiate from the beak.
   - 2b. Dorsal view of another specimen with the inner portion of the shell still remaining on the specimen. The posterior part is more crushed on the part immediately behind the beaks than represented in the figure, which may give a slightly incorrect idea of the shell.

3. *Monopteria? subalata.*
   - 3a. Side view of a left valve of one of the two type specimens.
   - 3b. Side view of the right valve of the other type specimen. The curve from the anterior to the ventral margin is a little full. Both in Mr. Rogers' collection.

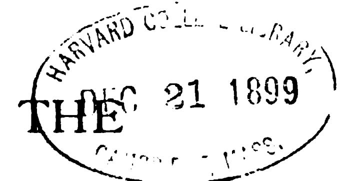
4. *Yoldia glaba.*
   - 4a. Side view of type.
   - 4b. Surface markings of the same enlarged. On the anterior margin there are additional marks of growth not indicated here. Specimen in Mr. Rogers' collection.

5. *Nucula pulchella.*
   - 5a. Side view of type, considerably enlarged.
   - 5b. End view of same, similarly enlarged.
   - 5c. Surface markings much more enlarged. Type in Mr. Rogers' collection.



Syd. Prentice, del.

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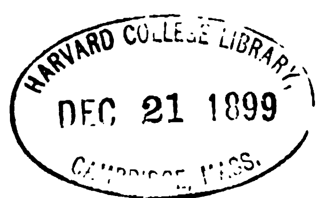
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BIBLIOGRAPHY OF SCIENTIFIC PUBLICATIONS BY MEMBERS OF THE UNIVERSITY OF KANSAS.

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Ph. B. (Yale, 1873); Ph. D. (Illinois Wesleyan, 1883). Instructor in Chemistry and Graduate Student, Yale College, 1873-'74; Instructor in Chemistry, Lehigh University, 1874-'83; Student Strasburg, Germany, 1881, and Leipsic, 1895; Professor of Chemistry, Metallurgy, and Toxicology, 1883—

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A. B. (University of Kansas, 1897). Student and Assistant, Department of Chemistry, 1895–'97; Scholar Cornell University, 1897–'98; Fellow Cornell University, 1898–'99; Assistant Professor of Chemistry, 1899—

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A. B., A. M. (1893); M. S. (Cornell University, 1895); Ph. D. (University of Chicago, 1896). Graduate Student and Assistant, Departments of Chemistry and Historical Geology; Professor of Physics and Geology, Wisconsin Normal School, 1897—

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B. S. (Wesleyan University, 1891); M. S. (Wesleyan University, 1892); Ph. D. (University of Chicago, 1897). Instructor in Chemistry, 1893–'94; Professor of Chemistry, Northwestern University Medical College, 1898—

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A. B. (University of Kansas, 1897). Fellow University of Chicago, 1898 —

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Dunstan, ARTHUR ST. CLAIR.

B. S. (Alabama Polytechnic, 1889); M. E. (the same, 1890); C. E. (the same, 1892). Graduate Student Johns Hopkins University, 1891–'92; Assistant in Physics, Alabama Polytechnic, 1892–'94; Assistant Professor of Physics and Electrical Engineering, 1894–'99; Associate Professor of Physics and Electrical Engineering, 1899; Professor of Physics and Electrical Engineering, Alabama Polytechnic, 1899—

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A. B. and B. S. (University of Kansas, 1884); A. M. and M. S. (1886). Special Instructor in Natural History, 1882–'84; Assistant in Natural History, 1884–'89; Professor of Zoölogy and Taxidermy and Curator of Birds and Mammals, 1890-- (Much of Professor Dyche's time for the last fifteen years has been devoted to building up the collection of North American mammals for the University of Kansas.)

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M. S. (Kansas Agricultural College, 1894); Ph. D. (University of Kansas, 1895). Graduate Student in Mathematics, 1891–'95; Assistant in Graphics, 1895–'97; Professor of Mathematics, Polytechnicum of Biel, Switzerland, 1897–'98; Professor of Graphical Mathematics, Kansas Agricultural College, 1898–'99.

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176. The Active Principle of Loco Weed: Notes on New Rem., ii, p. 1 (No. 12).
177. The Quality of Vegetable Extracts Resulting from the Use of Different Menstrums; Notes on New Rem., v, p. 3.
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Seiler, NELSON HUGHES.

Ph. G. (University of Kansas, 1893).

1893 — Vanillas; Proc. Kans. Pharm. Asssoc., p. 111.

Sheffer, THEOPHILUS H.

A. B. (University of Kansas, 1895). Student Department of Entomology.

1895 — Notes and Observations on the Twig Girdler, Oncideres cingulata Say; Insect Life, vii, pp. 345–347.

Slosson, EDWARD EMERY.

B. S. (University of Kansas, 1890); M. S. (1891). Graduate Student and Assistant, Department of Chemistry, 1890–'91; Professor of Chemistry, University of Wyoming, 1891—

1890 — 1. A Comparison of Preservative Fluids for Museum Use: Trans. Kans. Acad. Sci., xii, pp. 83, 84 (with V. L. Kellogg).

1892 — 2. The Relative Sweetness of Different Alcohols: Trans. Kans. Acad. Sci., xii, pp. 104, 105.

Smith, ANDREW JACKSON.

Ph. G. (University of Kansas, 1887).

1887 — Stramonium; Proc. Kans. Pharm. Assoc., p. 36.

1888 — Glycium and Borax; Proc. Kans. Pharm. Assoc., p. 111.

Snow, FRANCIS HUNTINGTON.

A. B. (Williams, 1862); A. M. (Williams, 1865); Ph. D. (Williams, 1881): LL. D. (Princeton, 1890). Principal High School, Fitchburg, Mass., 1862–'63; Clerk Fitchburg Paper Manufactory, 1863–'64; Student Andover (Mass.) Theological Seminary, 1864–'66; Professor of Natural Sciences and Mathematics, University of Kansas, 1866–'69; Professor Natural Sciences, 1869–'74; Professor Natural History, 1874–'89, and of Physiology, 1878–'89; Director of the Museum of Natural History, 1888—; President of the Faculties and Professor of Botany, Entomology, and Meteorology, 1889—; Chancellor of the University, 1890—

1868 — 1. Complete Series of Monthly and Annual Meteorological Reports from 1868 to the present time, based upon personal observations for that period. The reports are published monthly in bulletin form, and republished in many state papers. Annual reports are published in the Biennial Reports of the State Board of Agriculture.

2. The Study of Plants; Kans. Ed. Jour., v, pp. 4–6.

1870 — 3. Natural Science a Necessity in our Public Schools; Kans. Ed. Jour., vii, pp. 144–151.

1871 — 4. The Higher Education of Women; Kans. Ed. Jour., viii, pp. 307–321.

1872 — 5. Catalogue of the Birds of Kansas; Trans. Kans. Acad. Sci., i, pp. 375–386 (282 species enumerated); Kans. Ed. Jour., April, p. 8; Trans. Kans. St. Bd. Agric.

6. The Climate of Kansas; Trans. Kans. Acad. Sci., i, pp. 397–407; Trans. Kans. St. Bd. Agric.

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12. The Fishes of the Kansas River at Lawrence: An. Rep. Kans. St. Bd. Agric., iv, pp. 139–141.

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17. The Relation of Birds to Agriculture; Trans. Kans. St. Hort. Soc., vi, pp. 62–75.

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19. Amblychila cylindriformis Say; Trans. Kans. Acad. Sci., vi, pp. 29–32.

20. The Insects of Wallace County, Kansas; Trans. Kans. Acad. Sci., vi, pp. 61–71 (Coleoptera, 316 species; Lepidoptera, 45 species).

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22. List of Lepidoptera Collected in Colorado in June, July and August by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci., vi, pp. 70–75 (enumerates 104 species).

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1878—24. On the Dermal Covering of a Mosasauroid Reptile; Trans. Kans. Acad. Sci., vi, pp. 54–58, pl. i; Kans. City Rev. Sci.

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26. List of Lepidoptera Collected near Idaho Springs, Colo., by the Kansas University Scientific Expedition for 1879; Trans. Kans. Acad. Sci., vii, pp. 61–63 (enumerates 180 species).

27. List of Coleoptera Collected in Santa Fé Cañon, N. M., by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci., vii, pp. 70–73 (enumerates 237 species).

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31. Larva of Eurycreon rantalis Guen. (Web-worm); Psyche, iii, p. 127.

1881—32. List of Lepidoptera and Coleoptera Collected in New Mexico by the Kansas University Scientific Expedition; Trans. Kans. Acad. Sci., viii, pp. 35–46 (315 species Lepidoptera, 53 sp. nov.; 514 Coleoptera, 17 sp. nov.)

1882—33. Additions to the List of Kansas Coleoptera in 1881-'82; Trans. Kans. Acad. Sci., viii, p. 58 (49 species).

34. On Musca domestica versus Vespa occidentalis Cresson; Psyche, iii, p. 339.

35. A New Museum Pest, Trogoderma tarsale; Psyche, iii, pp. 351, 352, June.

1883—36. Three Noxious Insects—the Forest Handmaid-moth, the Maple-worm, and the Codling moth; Second Quart. Rep. Kans. St. Bd. Agric., pp. 93–101.

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38. Three Injurious Insects—the Tree-cricket, the Raspberry Saw-fly, and the Screw-worm; Mo. Rep. Kans. St. Bd. Agric. for May, pp. 6–12.

39. Injurious Insects and How to Destroy Them: First Quart. Rep. Kans. St. Bd. Agric., pp. 39–48.

1884—40. Insects Injurious to Wheat; Fourth Bien. Rep. Kans. St. Bd. Agric., ix, pp. 604–611, pls. i, ii.

41. Preparatory Stages of Hyperchiria zephyria Grote; Trans. Kans. Acad. Sci., ix, pp. 61, 62.

42. Lists of Lepidoptera and Coleoptera Collected in New Mexico by the Kansas University Scientific Expedition of 1883-'84; Trans. Kans. Acad. Sci., ix, pp. 65–69 (Lepidoptera 82, Coleoptera 148).

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46. Injurious Insects from July to September—the Hessian Fly, the Wheat-straw Worm, the Corn-root Worm, the Strawberry-root Worm, and the Grape Phylloxera; Quart. Rep. Kans. St. Bd. Agric. for quarter ending Dec. 31, pp. 152–157.

47. The Chinch-bug; Fifth Bien. Rep. Kans. St. Bd. Agric., x, pt. II, pp. 153–157.

48. Pear Blight; Rep. Kans. St. Bd. Agric. for quarter ending March 31, pp. 9–13.

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1887—50. The Purslane Worm, Copidryas gloveri Grote; Science, x, p. 204.

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53. Three New Kansas Birds; Trans. Kans. Acad. Sci., xi, pp, 62, 63.

54. A Comparison of the Records of the Two Anemometers at the University of Kansas; Trans. Kans. Acad. Sci., xi, pp. 107–109.

55. The Chinch-bug, Blissus leucopterus Say; Rep. Kans. St. Bd. Agric. for quarter ending March, pp. 127–131; Sixth Bien. Rep. same, pp. 205–208.

56. Insects Injurious to Wheat—the Hessian Fly and the Fall Web-worm; Fourth Bien. Rep. Kans. St. Bd. Agric., pp. 604–611.

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69. Experiments for the Destruction of Chinch-bugs in the Field by the Artificial Introduction of Contagious Diseases; Insect Life, iii, pp. 279–284.

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1892—71. Contagious Diseases of the Chinch-bug; Second An. Rep. Dir. Univ. Exp. Sta., pp. 1–56.

72. The Chinch-bug Disease and Other Notes; Insect Life, iv, pp. 69–72.

73. Chinch-bugs, Experiments in 1892 for their Destruction by Diseases; Eighth Bien. Rep. Kans. St. Bd. Agric., part II, pp. 248–255.

74. Two Grain Insects; Bul. Dept. Entom., Univ. of Kans., pp. 1–10, pl. (with V. L. Kellogg).

75. Experiments for the Destruction of Chinch-bugs by Infection; Psyche, vi, pp. 225–233.

1893—76. The Contagious Diseases of the Chinch-bug; Third An. Rep. Exp. Sta., Univ. of Kans., pp. 1–247, pl. iv.

1894—77. Contagious Diseases of the Chinch-bug; Fourth An. Rep. Exp. Sta., Univ. of Kans., pp. 1–50, pls. i–iv.

1894—78. Work in Economic Entomology at Kansas University for the Season of 1894; Insect Life, vii, pp. 141-144, figs.

79. Results of Chinch-bug Experiments; Quart. Rep. Kans. Bd. Agric., March, pp. 108-115.

80. Periodicity in Kansas Rainfall and Possibilities of Storage of Excess of Rainfall; Ninth Bien. Rep. Kans. St. Bd. Agric., pp. 338-340.

81. The Doctrine of Evolution, Commencement Address at Howard Payne College; Howard Payne Exponent, v, pp. 216-235.

1896—82. Contagious Diseases of the Chinch-bug; Sixth An. Rep. Dir. Univ. of Kans. Exp. Sta., pp. 1-39, pls. i-iv.

83. Popular Education in Europe; Rep. Kans. St. Bd. Agric., March, pp. 216-221.

1897—84. The More Destructive Grasshoppers of Kansas; Bul. Dept. Entom., Oct., pp. 1-17, pls. i-iv (with S. J. Hunter).

* Snow, William Appleton.

A. B. (University of Kansas, 1891); M. S. (1894); Assistant Professor Entomology, 1893-'96.

1891 — 1. The Moose Fly, a New Hæmatobia; Canad. Entom., London, Ont., xxiii, pp. 87-89.

1892 — 2. Notes and Descriptions of Syrphidæ; this journal, i, pp. 33-38, pl.

1894 — 3. Descriptions of North American Trypetidæ, with Notes; this journal, ii, pp. 159-174, pls. vi, vii.

4. American Platypezidæ; this journal, iii, pp. 143-152, pl.

1895 — 5. American Platypezidæ, second paper; this journal, iii, pp. 205-207.

6. Diptera of Colorado and New Mexico; this journal, iii, pp. 225-247.

7. Supplementary List of North American Syrphidæ; this journal, iii, pp. 249-262.

8. Cnephalia and its Allies; this journal, iii, pp. 178-186.

9. A New Species of Pelecocera; this journal, iii, p. 187.

10. On Toxotrypana of Gerstäcker; this journal, iv, pp. 117-119.

1896—11. List of Asilidæ, Supplementary to Osten Sacken's Catalogue of North American Diptera, 1878-'95; this journal, iv, pp. 173-190.

Steinberger, Earl Ira.

Ph. G. (University of Kansas, 1894).

1894 — Standardization of Drugs; Proc. Kans. Pharm. Assoc., p. 12 (with Reynolds).

Stevens, William C.

B. S. (University of Kansas, 1885); M. S. (1893). Teacher of Science, Emporia High School, 1885-'89; Assistant in Natural History, 1889-'93; Associate Professor of Botany, 1893-'99; Professor of Botany, 189—. Graduate Student at Marine Biological Laboratory, Woods Holl, 1890; Bonn, 1897.

1889 — 1. Water-supply of the City of Emporia; Fourth An. Rep. Kans. St. Bd. Health, pp. 278 280.

1990 — 2. Union of Cuscuta glomerata with its Host; Trans. Kans. Acad. Sci., pp. 163, 164.

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* Deceased.

1893 — 4. Apparatus for Physiological Botany; Bot. Gaz., xx, pp. 90-96, pls. ix-xii.

1898 — 5. Behavior of Kinoplasm and Nucleolus in the Division of Pollen Mother Cells of Asclepias cornuti; this journal, vii, A, pp. 77-85, pl. v.

6. Apparatus to Facilitate the Processes of Fixing and Hardening Material; this journal, vii, A, pp. 107-110.

7. Ueber Chromosomentheilung bei der Sporenbildung der Farne; Ber. der Deutsch. Bot. Ges., Band xvi, pp. 261-265, Taf. xv.

1899 — 8. Histology and Microtechnique (Part IV, Organic Materia Medica and Pharmacognosy, Sayre, pp. 491-663).

Stewart, ALBAN.

A. B. (University of Kansas, 1896); A. M. (1897). Graduate Student, 1896-'97; Student and Assistant in Paleontology, 1897-'99.

1896 — 1. Geological Section at Providence, Mo.; this journal, iv, pp. 161, 162, Jan.

1897 — 2. Restoration of Oreodon culbertsonii Leidy; this journal, vi, pp. 13, 14, pl. i.

3. Notes on the Osteology of Bison antiquus Leidy; this journal, vi, pp. 127-135, pl. xvii.

1898 — 4. Contributions to the Knowledge of the Icthyic Fauna of the Kansas Cretaceous; this journal, vii, A, pp. 21-29, pls. i, ii.

5. Individual Variations in the Genus Xiphactinus Leidy; this journal, vii, A, pp. 115-119, pls. vii-x.

6. Some Notes on the Genus Saurodon and Allied Species; this journal, vii, A, pp. 177-186, pls. xiv-xvi.

7. A Preliminary Description of Seven New Species of Fish from the Cretaceous of Kansas; this journal, vii, A, pp. 35, 36, pl. xvii.

1899 — 8. A Preliminary Description of the Opercular and Other Cranial Bones of Xiphactinus Leidy; this journal, viii, A, pp. 19-21, pls. x, xi.

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10. Notice of Three New Cretaceous Fishes, with Remarks on the Saurodontidæ Cope; this journal, vii, A, pp. 107-112.

11. Leptichthys, a New Genus of Fishes from the Cretaceous of Kansas; Amer. Geol., xxxiv, pp. 78, 79.

12. Notes on the Osteology of Anogmius polymicrodus Stewart; this journal, viii, A, pp. 117-121.

Thompson, W. F.

Ph. G. (University of Kansas 1893).

1893 — Use of Staining Agents in Microscopy; Proc. Kans. Pharm. Assoc., p. 149.

Weida, GEORGE FRANCIS.

Ph. G. (University of Kansas, 1888); Ph. D. (Johns Hopkins). Professor of Chemistry, Baker University, 1895—'97; Professor of Chemistry, Kansas State Agricultural College, 1897—

1888 — 1. Methods for the Assaying of Cinchona; Proc. Kans. Pharm. Assoc., p. 98.

1889 — 2. The Quality of Caustic Potash and Soda of the Market; Proc. Kans. Pharm. Assoc.

Wagner, GEORGE.

Ph. C. (Michigan University, 1893); A. B. (University of Kansas, 1899). Assistant in Pharmacy, Northwestern University, 1893-'95; Assistant Professor of Pharmacy, 1897-'99; Associate Professor of Pharmacy, 1899.

1893 — 1. Colocynth and its Adulterations; Proc. Amer. Pharm. Assoc., xli, p. 179.

1897 — 2. On Acetanelid in Phenacetine; Proc. Kans. Pharm. Assoc., p. 32.

1898 — 3. On Some Turtle Remains from the Fort Pierre — Contribution from Paleontological Laboratory No. 37; this journal, vii, A, pp. 201-203.

1899 — 4. On Tetracaulodon (Tetrabelodon) shepardi Cope; this journal, viii, A, pp. 99-103, pls. xxiv, xxv.

Walleck, ELLSWORTH F.

Ph. G. (University of Kansas, 1893).

1892 — Estimation of Colchicum and its Preparation; Proc. Kans. Pharm. Assoc., p. 108.

Watt, ROBERT ÆNEAS.

Ph. G. (University of Kansas, 1893).

1893 — Glucosides; Proc. Kans. Pharm. Assoc., p. 120 (with W. E. Wilson).

Wherrell, ORTA.

Ph. C. (University of Kansas, 1896).

1896 — Hemp, Hemp Seed, and Hemp-seed Oil; Proc. Kans. Pharm. Assoc., p. 17.

Whitten, WILLIAM M.

M. S. (Michigan University, 189-). Assistant in Chemistry, 189—

1897 — Chemical Composition of Some Kansas Cement Rocks; this journal, vi, A, pp. 29-34 (with E. H. S. Bailey).

Williston, SAMUEL WENDELL.

B. S. (Kansas State Agricultural College, 1872); A. M. (1875); M. D. (Yale, 1880); Ph. D. (Yale, 1885). Railroad Division Engineer, 1872-'73; Graduate Student, Department Chemistry, Kansas State Agricultural College, 1874; Student of Medicine, Iowa University, 1875-'76; Assistant in Paleontology and in Osteology, Yale College, 1876-'85; Assistant Editor *Science*, 1886; Demonstrator and Assistant Professor of Anatomy, Yale Medical School, 1886-'87; Professor of Anatomy, Yale Medical School, 1887-'90; Health Officer, City of New Haven, 1887-'90; Professor of Geology, etc., University of Kansas, 1890—

1877 — 1. On the Habits of Amblycheila cylindriformis; Canad. Entom., ix, pp. 164, 165, Sept.

2. The American Antelope; Amer. Nat., pp. 599-603, Oct.

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11. Are Birds Derived from Dinosaurs? Kans. City Rev. Sci., iii, pp. 215, 216.
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22. On the North American Asilidæ (Dasypogoninæ, Laphrinæ), with a New Genus of Syrphidæ; Trans. Amer. Entom. Soc., xi, pp. 1–35, pls. i, ii, Dec.
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27. Note on the Genus Merapiodus Bigot; Wien. Entom. Zeit., iii, p. 282, Nov.
28. Scopolia sequax, n. sp., in Notes on Injurious Insects; Entom. Lab. Mich. Agric. Coll., A. J. Cook, pp. 5, 6, ff.
29. Diptera; The Standard Natural History (Riverside Natural History), Cambridge, v, pp. 403–433.
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32. Notes and Descriptions of North American Xylophagidæ and Stratiomyidæ; Canad. Entom., xvii, pp. 121–128, July.
33. On the Classification of North American Diptera (first paper), Syrphidæ; Bul. Brooklyn Entom. Soc., vii, pp. 129–139, Feb.
34. On the Classification of North American Diptera (second paper); Entom. Amer., i, pp. 10–13, April.
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36. On Variations in Diptera; Entom. Amer., i, p. 20, April.
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41. Catalogue of the Described Species of South American Syrphidæ; Trans. Amer. Entom. Soc., xiii, pp. 308–324, Nov.
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46. Catalogue of the Described Species of South American Syrphidæ, Additions and Corrections; Entom. Amer., iii, pp. 27, 28.
47. Obituary of Oscar Harger; Amer. Nat., pp. 1133, 1134, Dec.
48. North American Tachinidæ, Gonia; Canad. Entom., xix, pp. 6–12, Jan.

1888—49. An Australian Parasite of Icerya purchasi; Insect Life, i, pp. 21, 22.
50. A New South American Genus of Conopinæ; Canad. Entom., xx, pp. 10–12, Jan.
51. Synopsis of the Families and Genera of North American Diptera, with Bibliography and New Species; 1878–'88, pp. 1–80, New Haven, J. T. Hathaway.
52. Hilarimorpha and Apiocera; Psyche, pp. 99–102, Oct.
53. Report on Rivers Pollution; An. Rep. Bd. Health Conn., 1887, pp. 176–266.
54. Leucopis bellula, n. sp., in Notes on the Cochineal Insect; Insect Life, i, pp. 258, 259.
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——— What Galenicals can Profitably be Made by the Pharmacist?

A NEW SPECIES OF SAGENODUS FROM THE KANSAS COAL MEASURES.

CONTRIBUTION FROM PALEONTOLOGICAL LABORATORY No. 50.

BY S. W. WILLISTON.

With Plates XXVIII, XXXV, XXXVI, XXXVII.

Sagenodus OWEN. "Body depressed, covered with large thin scales, almost quadrate in shape, but having the angles well rounded; both scales and external bones destitute of a ganoine layer. A large, median occipital plate posteriorly, with a smaller median plate immediately adjoining the front margin of this element; dental plates above and below triangular, irregularly ovate or elliptical in form, with a few strong, outwardly directed, more or less tuberculated or crenulated ridges; vomerine teeth resembling a single ridge of a dental plate; dorsal and anal fins continuous with the caudal." Woodward, Cat. Foss. Fishes Brit. Museum, ii, 256.

Twenty-one species of North American paleozoic dipnoans have been referred to this genus, based exclusively upon dental plates or scales; the generic determination of the latter species must be more or less uncertain. In the University museum there is a considerable collection of bones belonging to a species of this genus, which I cannot identify with any of the described forms. They were obtained by Dr. J. W. Beede at Robinson, in Brown county, this state. The horizon is rather above the middle of the Coal Measures, and the specimens were intimately associated with others of *Somphospongia* Beede, described in the last number of this journal.

Before discussing the species, I will give a list of the described species of the genus from North America, together with a brief diagnosis of the more important characters of each, so far as they can be gathered from the existing descriptions. Most of the species have never been figured, thus rendering the elucidation of the characters more difficult. The reference of the species, when not otherwise indicated, is upon the authority of Woodward (l. c.)

Sagenodus paucicristatus Cope, Proc. Amer. Phil. Soc., xvii, 1878, 53 (*Ceratodus*). Permian, eastern Illinois.

Dental plate 17 mm. in length from base of second ridge; four ridges present; surface minutely and elegantly corrugated.

Sagenodus fossatus Cope, ib., 53 (*Ctenodus*). Permian, eastern Illinois.

Dental plate 22 mm. in length; five crests present; crests coarsely dentate, with three or four teeth in each, the grooves between them marked by coarse, transverse, undulating grooves.

Sagenodus gurleianus Cope, ib., 54 (*Ctenodus*). Permian, eastern Illinois.

Number of ridges of dental plate uncertain, but probably not more than four; crests sharp, elevated, and coarsely dentate.

Sagenodus periprion Cope, ib., 527 (*Ctenodus*). Permian, Texas.

Length of dental plate, 47 mm; seven ridges present, their crests perfectly smooth and uniform.

Sagenodus porrectus Cope, ib., 527 (*Ctenodus*). Permian, Texas.

Length of dental plate, 38 mm.; crests six in number, each with four or five dentiform processes.

Sagenodus dialophus Cope, ib., 526 (*Ctenodus*). Permian, Texas.

Length of dental plate, 33 mm.; crests ten in number, with two or three other rudimental ones posteriorly; crests entire, except at the obliquely truncate distal extremity, where there are from two to four dentations.

Sagenodus pusillus Cope, ib., 101 (*Ctenodus*). Permian, Texas.

Length of dental plate, 7 mm.; crests four in number, each with two or three denticles, which are rectangular and little elevated.

Sagenodus vabasensis Cope, Proc. Acad. Nat. Sci. Phil., 1883, 110 (*Ctenodus*); Trans. Amer. Phil. Soc., xvi, 1886, 102 (id.) Permian, eastern Illinois.

Length of dental plate to marginal base of second crest, 24 mm.; six crests present; crests serrate nearly to their base, but the teeth are obsolete on their basal halves.

Sagenodus heterolophus Cope, Proc. Acad. Nat. Sci. Phil., 1883, 109 (*Ctenodus*). Permian, eastern Illinois.

Dental plate apparently with but three crests.

Sagenodus vinslovi Cope, ib., 1875, 410 (*Ceratodus*); Proc. Amer. Phil. Soc., xvii, 1879, 102 (*Ptyonodus*). Permian, eastern Illinois.

Coronal surface smooth, without irregularities or serrations; inner border with six notches.

Sagenodus serratus Newberry, Rep. Geol. Surv. Ohio, ii, 59 (*Ctenodus*); Paleozoic Fishes North Amer., 226, pl. xxxvii, f. 31 (id.) Coal Measures, eastern Illinois.

Dental plate 32 mm. in length, with eight sharp, radiating ridges, which terminate above in numerous, compressed, acute denticles, the furrows between the ridges being pitted to receive corresponding denticles of the opposite teeth.

Sagenodus occidentalis Newberry. Rep. Geol. Surv. Ill., ii, 19 (*Rhizodus*); Cope, Proc. Amer. Phil. Soc., xxxvi, 75. Mazon Creek shales.

Sagenodus reticulatus Newberry. Ib. 60; iv, 349, pl. iii, f. 9 (*Ctenodus*); Cope, Proc. Amer. Phil. Soc., xxxvi, 1897, 78, pl. i, ff. 2, 3. Coal Measures, eastern Illinois.

Dental plate 30 mm. in length, with seven low, radiating ridges; the whole crown of the teeth exhibits a fine, reticulate ornamentation, which, on the ridges, is more or less radiate, and has the appearance of hachures.

The following species are known only from the scales, while nearly all of the foregoing are known only by the teeth, usually a single crown. I reproduce Cope's table (Proc. Amer. Phil. Soc., xxxvi, 77, 1898) of nearly all those species based upon scales:

1. Concentric lines conspicuous 2
   No concentric lines 4
2. Tessellation and radii not conspicuous; scales medium to large, subround, *occidentalis*.
   Concentric lines fewer, marginal; tessellation conspicuous, radiating from a center 3
3. Scales medium to large, acuminate distad; tessellation very fine... *foliatus*.
   Scales small to medium, elongate, subacuminate; tessellation elongate, without regular radii or concentric ridges; center at extremity........ *reticulatus*.
   Scales medium to large, parallelogrammic; tessellation radiating, radii and concentric ridges extending to free edge; center at end............... *conchiopsis* (*conchiolepis*).
   Scales very large, elongate; tessellation confined to center, from which issue numerous, well-spaced radii.................. *lacovianus*.
   Scales medium, truncate; tessellation coarse, diamond-shaped, quincunciate.................. *quincunciatus*.
   Scales medium, truncate; tessellation coarser, parallelogrammic.. *browniæ*.
4. No concentric lines or center; a border of fine radii. Very large, elongate; tessellation very fine.................. *magister*.
   No concentric lines or radii; tessellation extending to posterior border. Scales deep, smaller; center submedian; tessellation of medium coarseness .... *gurleianus*.

Sagenodus foliatus Cope, Proc. Amer. Phil. Soc., xxxvi, 77, 1897, pl. i, f. 1. Mazon Creek shales.

Sagenodus conchiolepis Cope, ib., 79, pl. i, f. 4. Mazon Creek shales.

Sagenodus lacovianus Cope, ib., 79, pl. i, f. 5. Mazon Creek shales.

Sagenodus quincunciatus Cope, ib., 80, pl. i, f. 6. Mazon Creek shales.

Rhizodus reticulatus Newberry, Geol. Surv. Ill., iv, pl. iii, ff. 13, 14.

Sagenodus browniæ Cope, ib., 81, pl. i, f. 7. Mazon Creek shales.

Sagenopus magister Cope, ib., 81, pl. i, f. 8. Mazon Creek shales.

Sagenodus gurleianus Cope, ib., 82, pl. i, f. 9 (*nomen bis lectum*).* Mazon Creek shales.

Sagenodus quadratus Newberry (*fide* Cope l. c.)

* *Sagenodus*; Hay, Amer. Nat.

Sagenodus copeanus, n. sp.

Dental plates of upper jaws elongate, the inner curve parabolic-like, becoming greater posteriorly. Anteriorly the ridge bordering the plate becomes very pronounced, and terminates in a prominent point. The succeeding ridges become less and less prominent and less oblique, the fifth running transversely, the last, or ninth, merely forming a tubercle on the outer margin. The nine ridges include the borders of the plate, there being eight depressions between them, the last scarcely distinguishable, and short. The general surface of the crown is concave and smooth, the ridges sharp, and terminating in tooth-like points. The coronal surface is everywhere smooth, without denticles, tubercles, or pittings. The palatine plate below the dental plate anteriorly on the inner side is gently concave. The border for union with its mate is straight and very oblique, terminating about opposite the third dental serration; posteriorly the dentigerous plate is strongly convex above, arching outward as far as the hind end of the dental plate. Above this convexity the inner surface is gently concave, and the plate is here very thin. On the upper border, beginning a little way back of the symphseal border, there is a narrow sutural surface for union with the parasphenoid or basale. At the posterior extremity the broad end is beveled outward into a thin border, and is cut off nearly transversly. Externally the surface is flattened and very oblique above the margin of the dental plate. Back of this the surface is more flattened vertically, with a narrow portion on the upper part turned inward. Where this surface turns inward, there is an elevation and roughening, as though for cartilaginous or bony union.

The pterygopalatine plate, while shaped much as in *Ceratodus*, differs markedly in being less elongate posteriorly, more expanded and nearly squarely truncate. The anterior ends of the dentigerous plates evidently approach each other more closely than in *Ceratodus*, the innermost ridge and its projecting tooth lying more closely together, with only a narrow interval between them.

None of the bones found in the rock are in connection, or but very few of them are. The determination of many must be very difficult at present, since so little is known of the anatomy of allied forms. It is very evident that the ossification of the skeleton is more extensive than in *Ceratodus*, though many of the bones, especially the vertebræ, remained cartilaginous. So many of the shield bones of the head are present that one will readily eliminate from them the bone which seems certainly to be the parasphenoid or basale of Guenther. It is diamond-shaped, with a moderately long posterior projection. The surface that seems to be the upper one is smooth, gently concave in the middle, with a median ridge beginning near the middle and be-

coming quite prominent at the beginning of the prolongation, when it again decreases in height and disappears. The four sides of the diamond are of nearly equal length, and the figure almost a square. The anterior lateral borders show sutural surface, the bone projecting somewhat irregularly to underlap the pterygopalatines. The inferior or buccal surface is gently convex transversely towards the front, more nearly flat posteriorly. It is conspicuously marked by two narrow ridges, beginning near the middle and running one to each angle of the base of the posterior prolongation, and then disappearing in the thin upturned alate margin. The surface between these ridges is concave and striate. Anteriorly the bone is marked by an upraised surface in the form of a long triangle, with its apex at the middle. The posterior process is thinned and narrowed posteriorly.

The relations between the pterygopalatines and the basisphenoid are shown in plate xxxvii, figure 2. One cannot be sure that the relative sizes of the two bones are correctly expressed, since the several jaws in the collection vary somewhat in size. From the sutural surface on the pterygopalatines, however, I believe the proportions must be about as drawn.

The splenials with the dental plates are much narrower than are the pterygopalatines and upper dental plates. The specimen upon which the following description is based is a practically complete splenial and dental plate. The inferior border of the splenial is very thin and sharp. The sutural surface for union with its mate is thickened and flat; the lower half only is preserved in this specimen. Back of the symphysis the inferior border is gently concave, when seen from the side, to near the hind end, where it becomes convex, ending in a point. The upper border, back of the dental plate, is also thin, and is curved sigmoidally to the tip. On the convexity of the curve there is a slight roughening, as though for union with the articular. The distal end is curved outward, as in *Ceratodus*, to include the articular cartilage. The inner surface below the dental ridge is smooth throughout, gently concave, and standing nearly vertically or slightly inclined outward back of the anterior portion. In front the surface turns inward to form a broad channel when in apposition with its mate. In general the shape of the splenial is much like that of *Ceratodus*, but is much more slender and elongated, the sigmoid curve back of the dental plate less pronounced, and the excurved articular end more slender.

The inner border of the dental plate corresponds to that of the upper dental plates, though less strongly curved. This border forms a strong ridge overhanging the inner surface. The general surface of

the crown is convex, to correspond with the concavity of the upper dental plate, and the ridges are directed like them, but are shorter and rather less strong. The ridges, furthermore, extend very nearly to the inner margin, not fading out at some distance from it as do they in the upper plate. There are eight ridges. corresponding to the grooves of the upper plates. The grooves are deeper outwardly than are the upper grooves. The plate altogether is more slender than the upper ones.

The splenial plate has been figured in union with a mate in a position to correspond with the upper plates, and the other bones of the mandible are outlined from *Ceratodus*. (Pl. xxxvii, fig. 1.)

Several large and well-ossified bones of an oval-concave shape are present in the rocks. Several of them have been removed nearly complete, and are shown in plates xxviii, xxxv, and xxxvi. They resemble not a little a valve of a pelecypod. The outer surface is strongly convex, one end more or less sharply truncate, the lower border strongly convex, the upper border with a flattened tooth-like process, on either side of which the border is more nearly straight. The border everywhere is thin, the inner surface concave, and there are no indications of sutural attachments, unless it be on the truncated end. It would seem probable that the bone is an opercular, although there is no surface indicated for the attachment of the subopercular.

Another bone, that may be the subopercular, is of smaller size than the foregoing. (Pl. xxxvi, fig. 3.) It is somewhat fan-shaped in outline, the outer surface convex, the border thin, the inner surface concave. The inferior lateral border is nearly straight, meeting the expanded border nearly in a right angle; the other lateral border is strongly convex, and is inflected inward; on the convex surface there is a convex depression on the inflected portion. The surface between this line and the convex border evidently was in apposition to some other bone, perhaps the preceding.

A bone, which from its resemblance to the ceratohyal of *Ceratodus* may be that, is shown in plate xxviii, figures 3, 3*a*, and 3*b*. The upper end is oval, truncated squarely, and with a deep conical cavity, reaching nearly to the middle of the bone, the bone itself being merely a shell. The lower extremity, more elongated, is also deeply hollow. The border represented in figure 3*a* is broadly rounded. Near the middle of the surface shown in figure 3 there is a vertical, rather sharp ridge, standing out abruptly from the bone, and evidently for muscular or cartilaginous attachment. On the other surface a thin flat plate extends obliquely backward from the bone. Its whole extent is not preserved. Three or four of these bones are preserved in the collection, but none are complete.

A number of other bones of indeterminable relationships are shown in plates xxviii and xxxv, and there are several others too incomplete to figure. They are for the most part thin, and probably represent among them the pectoral and pelvic girdles in part.

Numerous bones of the roof of the skull are in the collection. Some of the more perfect specimens are shown in plate xxxv. The surface exposed when in the rock is almost invariably the inner, since the outer surface is more roughened and less easily separable from the matrix.

The material in which the bones occur is an exceedingly hard limestone, permitting but very little manipulation. The bones exposed are due to fortunate splitting of the matrix. Doubtless with more complete examination of the horizon in which they occur the complete anatomy of these interesting dipnoans will be brought to light.

NORMAL ANKERITE FROM PHELPS COUNTY, MISSOURI.

BY AUSTIN F. ROGERS.

ANKERITE is a subspecies in the calcite group of carbonates to which Boricky has assigned the formula: $CaFeC_2O_6 + n$ (Ca MgC_2O_6), with n varying from one-half to ten. Normal ankerite is: $CaFeC_2O_6 + CaMgC_2O_6$, or $2CaCO_3 + MgCO_3 + FeCO_3$.

As the mineral here described was found, upon analysis, to agree so closely with the theoretical for normal ankerite, a published account of it was thought not to be out of place. It was found by the writer at an abandoned "iron bank" about six miles southwest of Rolla, Phelps county, Missouri, in 1897. The mineral occurs in crystalline masses containing numerous small cavities and cracks occupied by minute crystals, which are covered with a thin coating of iron oxide. The associated minerals include massive hematite, siderite, and calcite, showing rhombohedral cleavage, and large crystals of amethyst.

The physical properties of the ankerite are as follows: Cleavage, rhombohedral; specific gravity, 2.99; luster, vitreous, inclining to pearly; color, salmon; subtranslucent.

An analysis was made of selected pieces containing no appreciable amount of the iron oxide. Calcium, magnesium and iron were determined by the well-known methods and calculated as oxids and carbonates. Carbon dioxid was determined by loss. The results given below are the means of several determinations.

			Theory for normal ankerite.
CaO		28.41	28.00
MgO		10.20	10.03
FeO		17.22	18.00
CO_2		44.21	43.97
Total		100.04	100.00
		Ratio.	
$CaCO_3$	50.74	2.00	50.00
$MgCO_3$	21.34	0.99	21.00
$FeCO_3$	27.75	0.94	29.00
Total	99.83		100.00

The ratio of $CaCO_3 : MgCO_3 : FeCO_3$ is very near 2:1:1, which is that for normal ankerite. This analysis agrees more closely with the theoretical for normal ankerite than any published analysis I have been able to find.

MINERALOGICAL LABORATORY, Univ. of Kans., September 22, 1899.

NOTES ON THE CORACO-SCAPULA OF ERYOPS COPE.

CONTRIBUTION FROM THE PALEONTOLOGICAL LABORATORY No. 51.

BY S. W. WILLISTON.

With Plates XXVII, XXIX, and XXX.

A PART only of the coraco-scapula of *Eryops* has hitherto been made known, and figured, by Cope. In a specimen comprising a large part of the skeleton, collected by Mr. C. N. Gould, from the Red Beds of the Indian territory, near the southern line of Kansas, a nearly complete coraco-scapula has been removed from the matrix, and is figured herewith in plates XXVII and XXIX.

The bone is elongated, and nowhere very thick or massive. The distal part of the scapula is much thinned and considerably expanded; the immediate margin here, however, is wanting, so that the precise outlines cannot be given.

The position of the two bones must have been very oblique, as is evident from the position of the glenoid cavity. The postero-inferior border is moderately thickened, and rounded; gently concave along the proximal part and convex distally. The antero-superior border is much thinner than the opposite one, and is concave throughout the extent of the shaft, except distally, where it is coossified with the procoracoid. The union of these two bones is very close in this region, the sutural line being distinguished with difficulty, if at all. The procoracoid is narrower and more thickened below, reaching to the lower part of the conjoined bone, and lying in close apposition, though not suturally united. Both the lateral surfaces of the scapula are nearly flat. A little proximad to the narrowest part of the shaft the bone is much thickened by a stout ridge on the inner side, which includes between it and the remainder of the bone, just back of or above the cotylus, a large, elongated foramen, both of whose orifices can be seen from the inner side of the bone only.

The glenoid surface is elongated and deeply concave in its long diameter. The scapular portion is much smaller than the coracoid, and is partly separated from it by a constriction; this surface is nearly flat and is placed at right angles to the plane of the coracoid surface, looking directly downward when the bone is lying horizontally. The rest of the cotylus is moderately concave and looks outward, and

somewhat backward and upward with the bone in its former position. Just how much of the conjoined bone is formed of each element it is impossible to say, since the union is so close that no trace of junction is perceptible. Evidently, however, the coracoid forms only a small part of the whole bone. Its anterior or inferior border is gently convex, the posterior one slightly concave.

The anterior end of the superior border of the scapula is gently convex, as is also the broad external surface. On the inner side the foramen described above opens into a deep, elongated, boat-shaped cavity at its distal end, the cavity formed by the upper border of the ridge described. In the lower or anterior end of the cavity there are apparently two smaller foramina, the exterior orifices of which are just within the anterior margin of the scapular face of the glenoid surface. The proximal surface of the scapula is concave; that of the coracoid, if the bone is limited by the ridge spoken of, is for the most part gently convex and lies in a more mesial plane.

In comparison with the same bones of *Dimetrodon*, as figured and described by Baur and Case (Trans. Amer. Phil. Soc., N. S., xx, p. 46, pl. iii, fig. 30), the bone is much less concave along its lower border, more expanded proximally, the coracoid evidently smaller and not bifid below, the glenoid surface smaller and broader, and the bone a little larger.

In plate xxx is shown the outside view of a part of the lower jaw and two views of a skull bone of undetermined location. They will be described more fully in a future communication.

EDITORIAL NOTES.

THE writer has been convinced for some time that purely laboratory methods have been carried to an extreme in many institutions in biological instruction; the pendulum has swung too far in the opposite direction from purely didactic instruction. Systematic biology is, after all, the highest expression of zoölogy or botany, and to completely ignore such must result in an imperfect and faulty training. A minute knowledge of a few types of the animal or plant kingdom is not zoölogy or botany, but morphology, and morphology cannot replace zoölogy or botany. Furthermore, many teachers lose sight of the fact that all students are not seeking to become specialists, and require altogether too much time spent in the study of methods. A recent text-book by Professor Kingsley * seems to the writer to be a praiseworthy advance in the teaching of its department of biology. The author recognizes what is emphatically true, that laboratory observation and facts are not science. It is utterly impossible for the pupil to learn all that he should of animal life from personal observation; he must and he should depend upon didactic instruction for a very large share of necessary knowledge. This text-book, which treats of the vertebrates only, is in two parts, one dealing with embryology and development, the other with classification, both of which are generally neglected for pure morphology, and both of which are of as great or greater importance. The classificatory part deals, as it should, with the whole vertebrate kingdom and not with that smaller portion which happens to be in existence at the present time. The plan of the work is excellent; its faults are chiefly those of too great haste. As the author truly states, the labyrinth of material is such that errors are unavoidable, especially when any new line of treatment is attempted. The work would, however, have been improved had it been subjected to more thorough revision in the classificatory part. Nevertheless, the work is to be commended. S. W. W.

* * * * * * *

IT IS becoming a serious question in medical education where to limit instruction. A score of years ago the student could cover the whole field fairly well in three years, but specialization has increased so rapidly that the student is now fairly swamped with the material that he is expected to acquire in the four years of his course. This is true in every branch of medical education; even in anatomy, where it would be supposed the increase of knowledge has not been so extensive. Excellent works have been published on anatomy in late years, but they are rapidly losing the nature of text-books and assuming that of manuals—they are splendid works for the shelf of the physician or surgeon, but are altogether too prolix and full for the student's needs. Between such manuals and the compends there has been no middle ground. In the "Text-book of Anatomy by American authors," † recently published, a work that may be justly called a text-book has appeared. A number of useful features have been added to the

*Text-book of Vertebrate Zoology, by J. S. Kingsley, professor of zoology in Tuft's College. New York: Henry Holt & Co., 1899.

† A Text-book of Anatomy by American Authors, edited by Frederic Henry Gerrish, M. D., illustrated with 950 engravings in black and colors, Lea Bros. & Co., 1899.

work, as in the attachment of muscles, regional and surface anatomy, etc., but its chief excellence lies in what is omitted. It is not a manual, and will not take the place of such works for the surgeon, but it is a text-book par excellence, and, in the opinion of the writer the best English text-book for medical students that has ever been written. That is all the commendation it needs. S. W. W.

* * * * * * *

THE NEW UNITED STATES DISPENSATORY (18th ed.) Edited, revised and rewritten by H. C. Wood, M. D., LL. D., Joseph P. Remington, Ph. M., F. C. S., F. L. S., Samuel P. Sadtler, Ph. D., F. C. S. Thoroughly revised, with comments on the new British Pharmacopœia, and including the vast number of new synthetic remedies and the latest additions in materia medica, therapeutics, and pharmacy; 2045 pages: J. B. Lippincott & Co., Philadelphia.

The progress of medicine and pharmacy within the past few years has been such as to make the appearance of the revised edition of this standard authority in medicine one of great interest not only to physician and pharmacist but to students in many departments of service. From the very first (1833) the United States Dispensatory has, by mutual consent, been regarded as the highest authority and the most valuable commentary upon the pharmacopœias of the world. In this particular it has not to this day lost its supremacy. It is with no little interest, therefore, that we glanced through its pages to see what influence the chemical laboratory had made upon medical science. It is well known that our materia medica has been expanded and possibly enriched by the introduction of what are known as new remedies—mainly the products of the German laboratories. The vast increase of synthetical remedial agents and the appearance of the new British Pharmacopœia has evidently made the editorial work in this new edition an enormous task. The work has been done in the same excellent manner which characterizes all of the work of Professors Wood, Remington, and Sadtler, each a recognized authority in his special department. The one point of criticism the reviewer of the work is inclined to make, which, however, in no way applies to the work of the authors, relates to this process of "expansion." Our materia medica is becoming too heavily burdened with *material*. A process of elimination must soon take place. We should soon commence to contract—to sift the wheat from the chaff. This will be one of the principal tasks of the next committee of revision of the United States Pharmacopœia. Overburdened as the United States Dispensatory is with much of this chaff, we would say that those who would keep abreast of the time in all that pertains to medicine cannot afford to be without this encyclopedia of pharmacy, chemistry, materia medica, and therapeutics. L. E. SAYRE.

* * * * * * *

ORGANIC MATERIA MEDICA AND PHARMACOGNOSY; 700 pages: P. Blakiston's Son & Co., Philadelphia.

Among the books which have reflected credit on the University of Kansas, we note with pleasure the appearance of a second edition of this work.

The work under consideration is an introduction to the study of the vegetable kingdom and the vegetable and animal drugs, comprising the botanical and physical characteristics, source, constituents, and pharmacopœial preparations, including a chapter relating to the insects injurious to drugs, by Lucius E. Sayre, B. S., Ph. M., dean of the school of pharmacy and professor of materia medica and pharmacy in the University of Kansas, member of the committee of revision of the United States Pharmacopœia; with histology and microtechnique, by William C. Stevens, M. S., professor of botany in the University of Kansas.

The book has been thoroughly revised and in the greater part rewritten, and

contains nearly 700 pages, with 374 illustrations. It has been enlarged nearly 150 pages.

The author is to be congratulated on the merited success this book has attained, as the first edition appeared barely four years ago.

The subject-matter is exceedingly well arranged for use as either a text or reference book, and is especially adapted to the requirements of students or practitioners in either pharmacy or medicine. A unique feature of the second edition is an epitome of the manner of isolation of the active principles, usually alkaloids, appended to the important drugs.

In part IV Professor Stevens deals with the elements of plant histology and microtechnique in a clear, accurate and concise manner, indicative of a thorough understanding of the subject. This is a valuable addition to the book, as it supplies a long-felt want and growing need to the practical pharmacist.

In the revision we regret the omission of the chapter on morphological structural botany and the glossary, as they supplied a completeness desirable in works of this kind, but hope they may be reinstated when a future revision becomes necessary. Considering the price and excellence of the work, it should be accorded a place in the library of every progressive pharmacist and physician.

L. D. HAVENHILL.

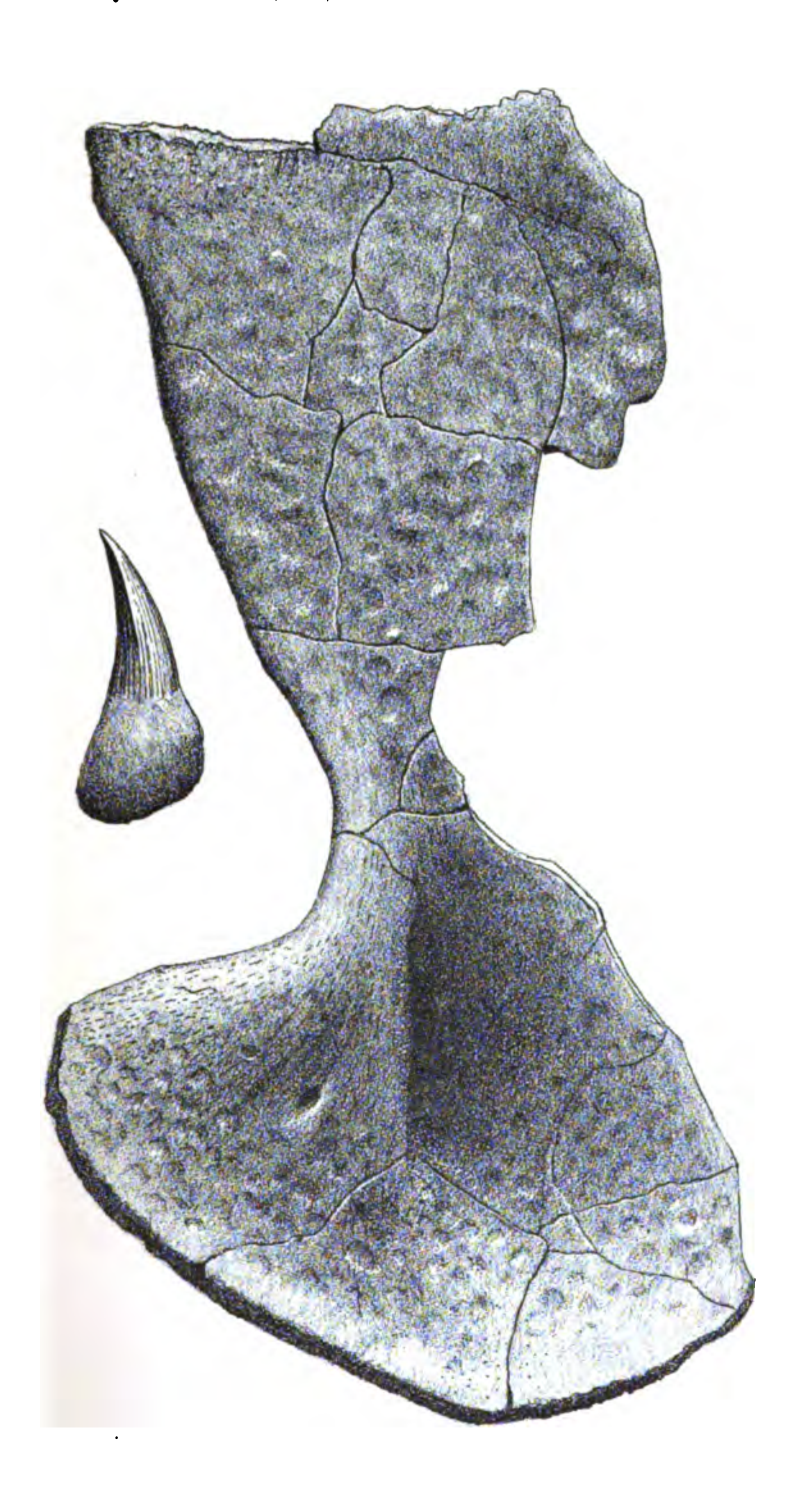
WILLIAM APPLETON SNOW, a former contributor to this journal, was drowned in San Francisco bay on the night of October 10th last. Mr. Snow was the oldest son of Chancellor Snow, and was born in Lawrence June 21, 1869. He graduated from the University of Kansas in 1891, and filled positions as instructor in entomology in his *alma mater*, in the University of Illinois, and in the Leland Stanford Junior University. In the course of the past year he had resolved to devote himself to journalism, for which he had taste and talent, and it was in pursuit of his new profession, while on the press tug that met the incoming transport Tartar with the Twentieth Kansas volunteers, that he was washed overboard and was drowned.

Mr. Snow's scientific publications are enumerated elsewhere in this number. Most of them appeared in this journal. For his years he had accomplished much as a specialist in diptera, and his contributions have a permanent value. He was a warm-hearted, amiable gentleman, and his taking off is mourned by many friends wherever he was known. Memorial services were held in Lawrence November 12, 1899, in which Doctor Cordley, Professor Williston and Mr. W. A. White participated. A full report of their remarks was printed in the Lawrence *Journal* of November 13, 1899.

PLATE XXVII.

Eryops megacephalus **Cope.**

Left coraco-scapula, inside view, half natural size.
Tooth natural size.



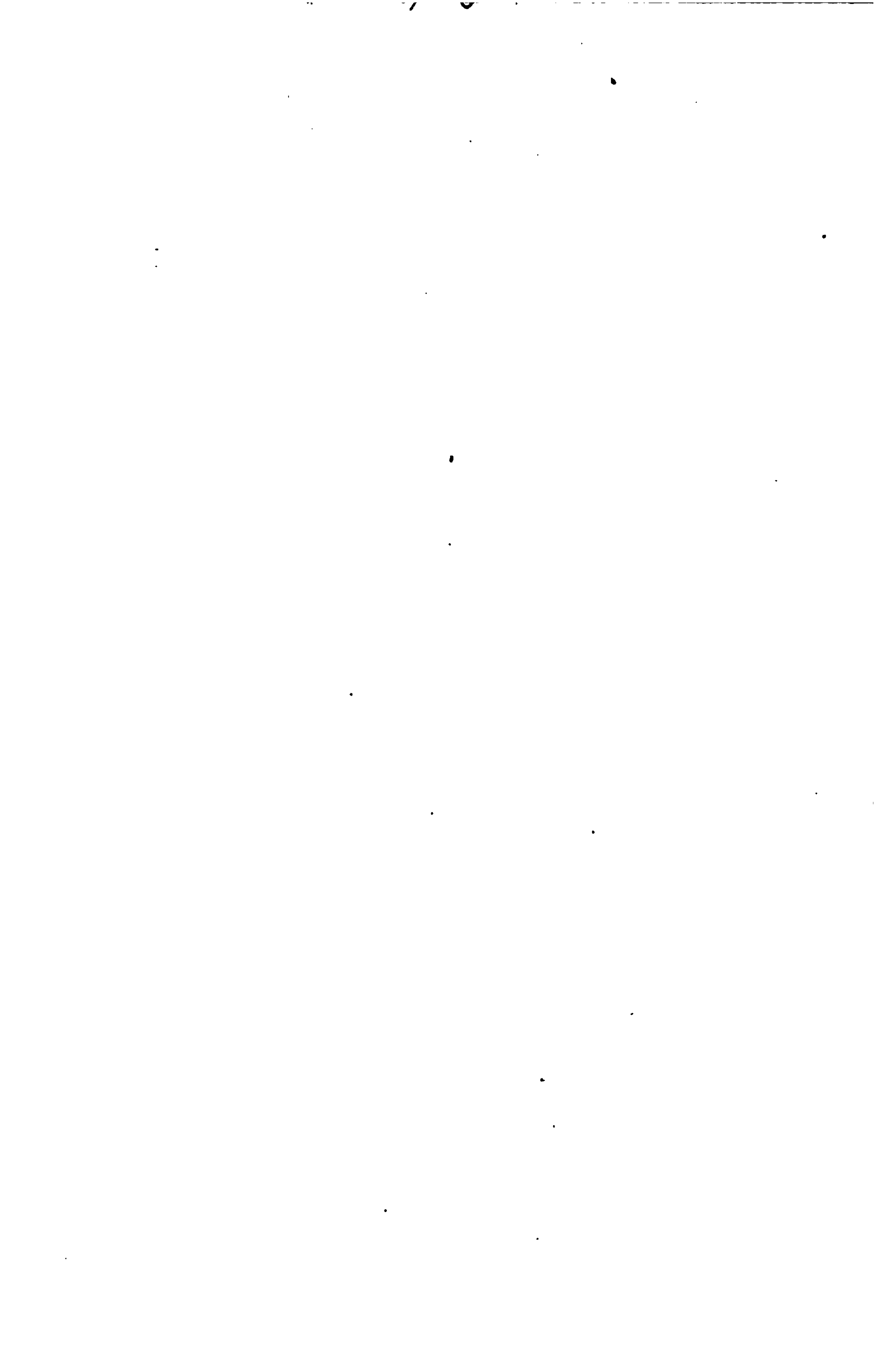


PLATE XXVIII.

Sagenodus copeanus **Will.**

Fig. 1.—Left splenial bone, inside view.
Fig. 2.—Right pterygopalatine, inside view.
Figs. 3, *3a*, *3b*.—? Ceratohyal.
Figs. 4, 6.—Undetermined bones.
Fig. 5.—? Operculum.

All figures natural size.

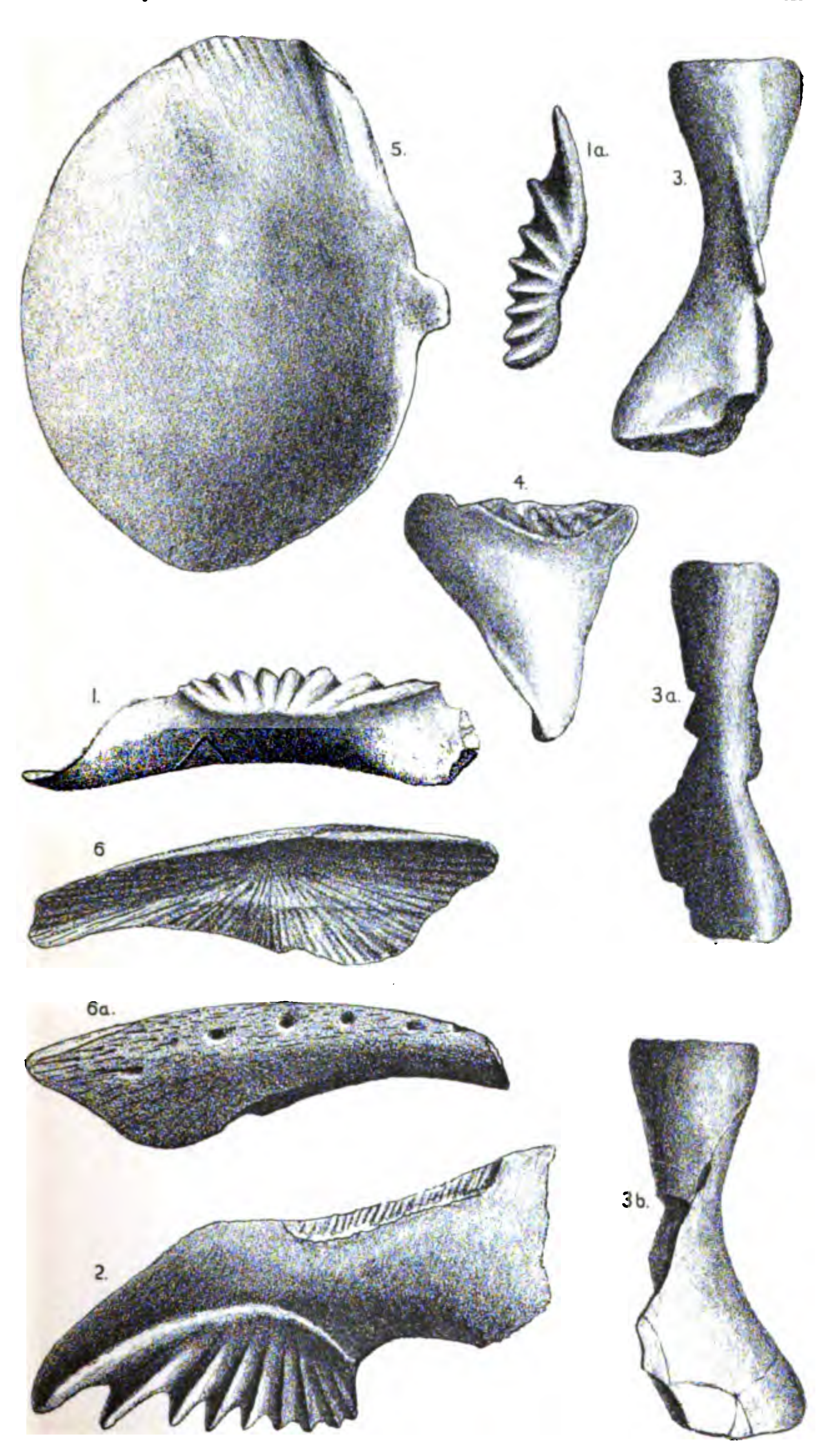

5.
1a.
3.
4.
1.
3a.
6
6a.
3b.
2.

PLATE XXIX.

Eryops megacephalus **Cope.**
Left coraco-scapula, outside view.
Half natural size.



PLATE XXX.

Eryops megacephalus Cope.

Fig. 1.—Left mandible.

Figs. 2, 2*a*.—Undetermined bone.

Half natural size.

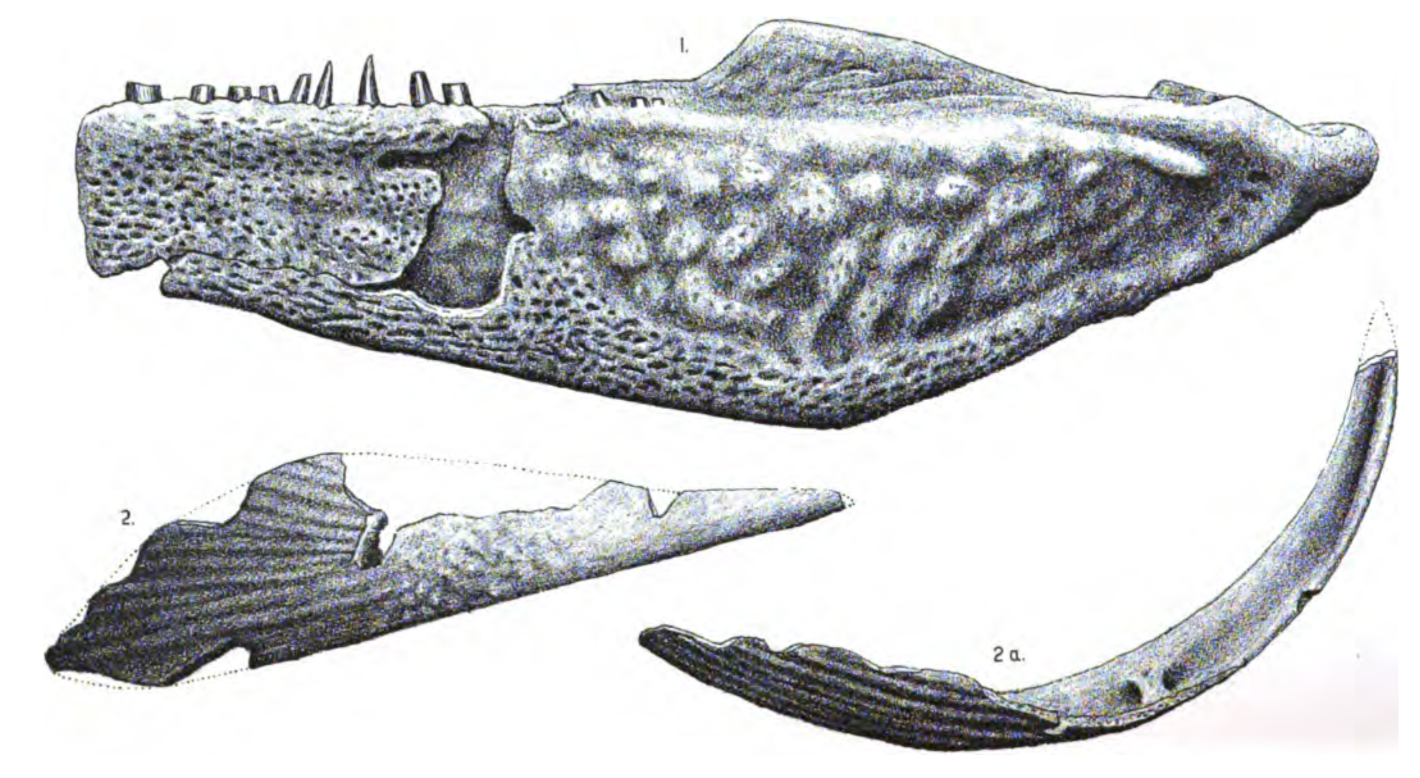

1.
2.
2 a.

PLATE XXXV.

Sagenodus copeanus.

Figs. 1, 4.—Undetermined bones.

Figs. 2, 2*a*.—Opercular (?), from without and within.

Fig. 3.—Parasphenoid, from above.

Figs. 5-14.—Shield bones of head.

Figs. 5, 6, 7.—The same element.

Fig. 6.—Shows a portion of two other bones attached.

All two-thirds natural size.

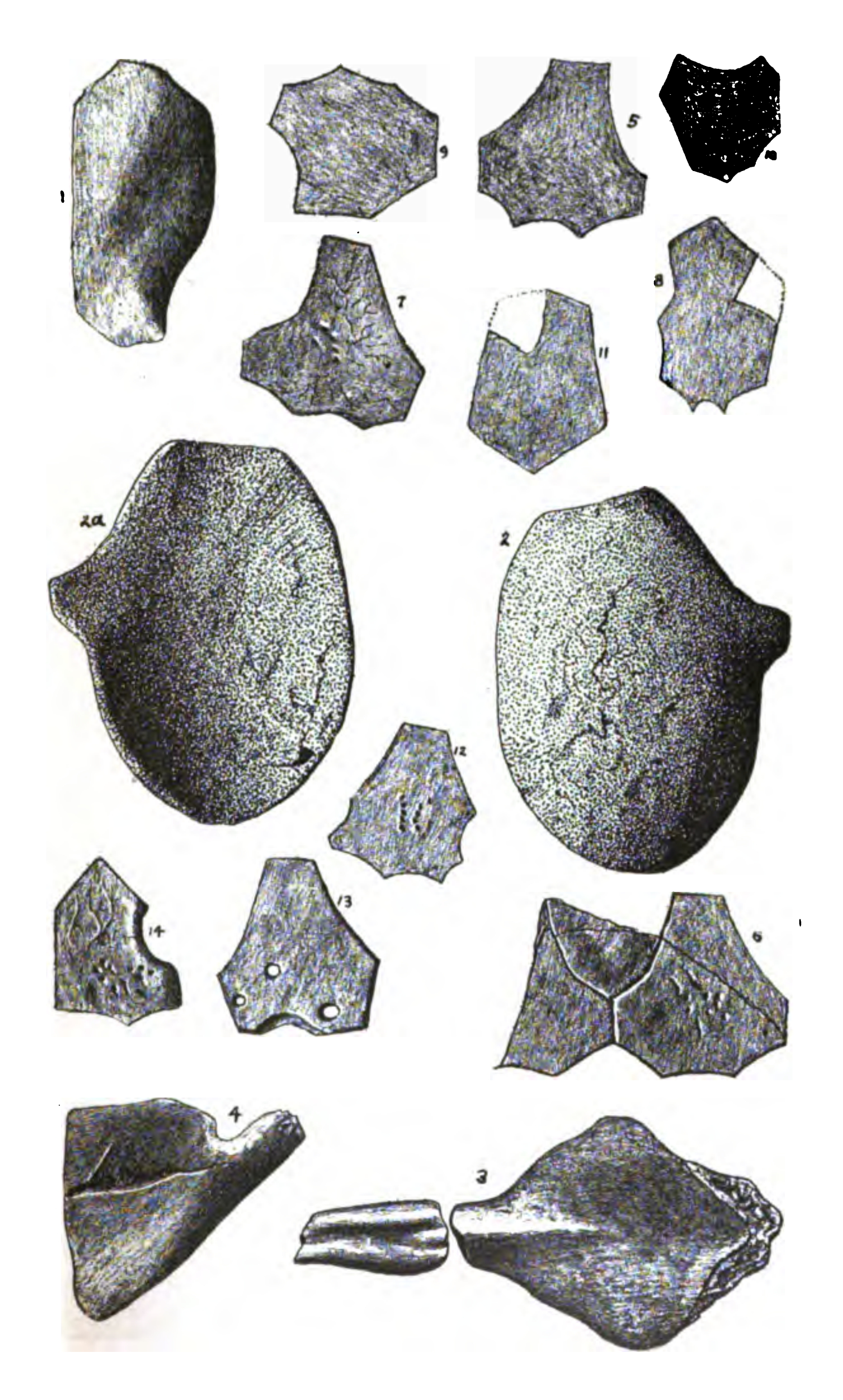

1
9
5
10
7
11
8
2a
2
12
14
13
6
4
3

PLATE XXXVI.

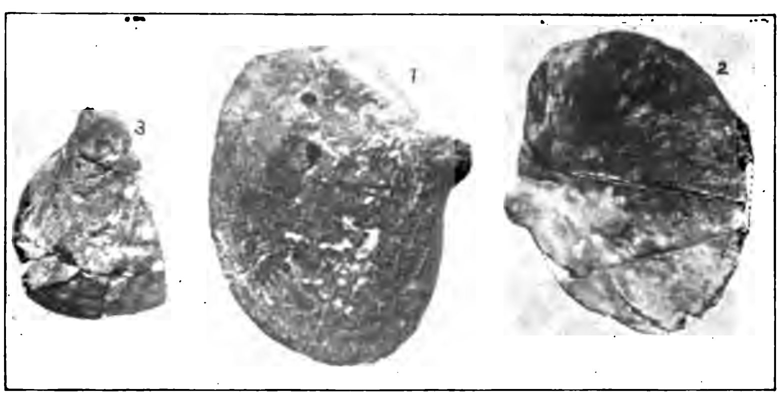
Sagenodus copeanus.

Figs. 1, 2.—Opercular (?).

Fig. 3.—Subopercular (?).

All a little more than one-half natural size.

Top figure, another, larger specimen of the opercular, about three-fourths natural size.


3
1
2

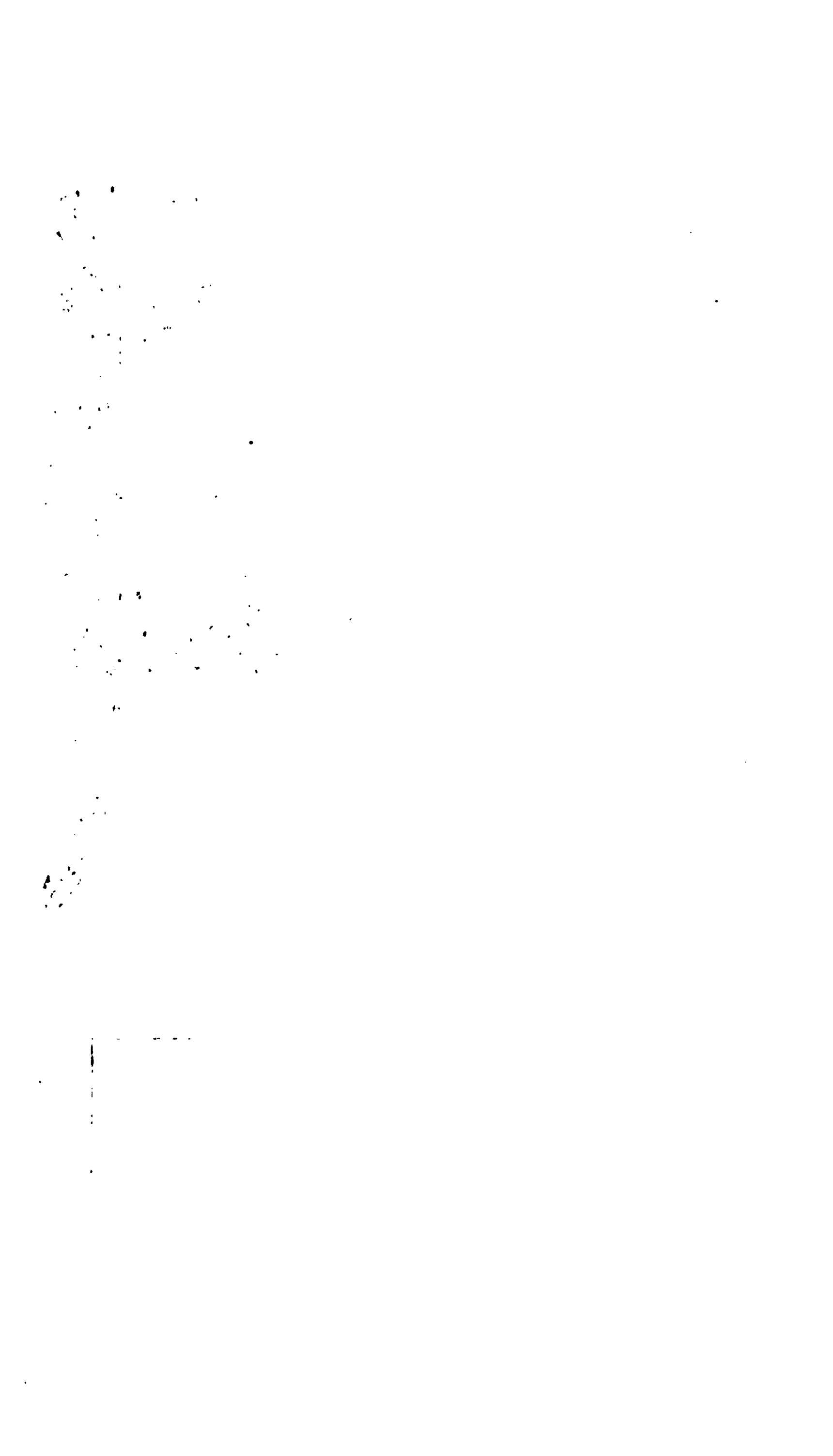


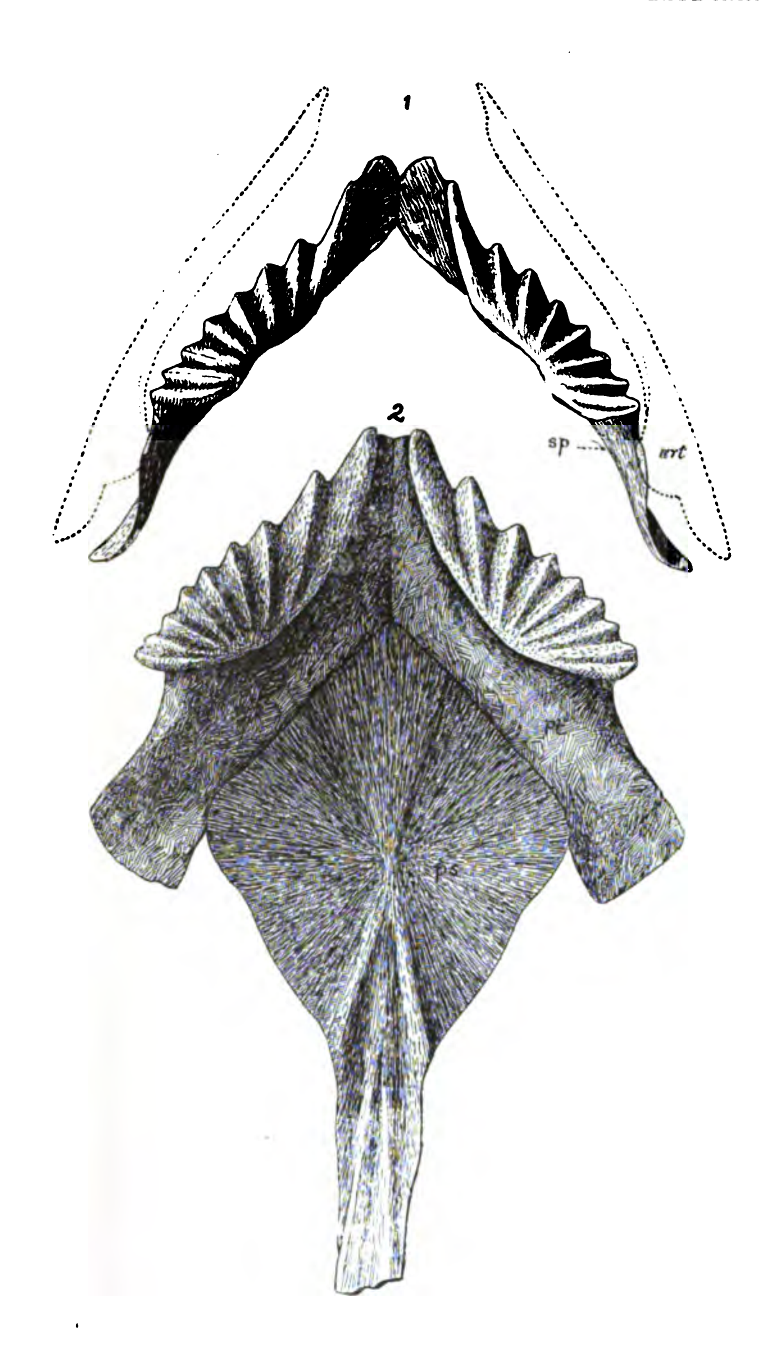
PLATE XXXVII.

Sagenodus copeanus.—Restoration.

Fig. 1.—Mandibles: *Sp.*, splenial; *Art.*, articular.

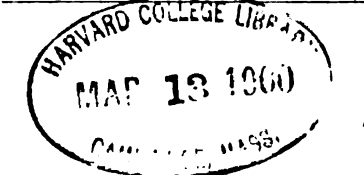
Fig. 2.—*Pt.*, pterygopalatine, with dental plate; *Ps.*, parasphenoid.

All natural size.


1
2
sp
art
pt
ps


Columbia

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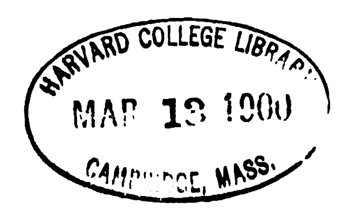
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KANSAS UNIVERSITY QUARTERLY.

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THE PARTITION OF AFRICA—A REVIEW.

BY E. D. ADAMS.

SOME four hundred years ago Columbus, searching for a new route to the Indies, stumbled upon a new world, the continent of America. At about the same period, and with a similar purpose in view, the mariners sent out by Prince Henry, of Portugal, rounded the Cape of Good Hope, and made landings here and there upon the east coast of Africa. America, with a population entirely barbarian, yielding slowly to conquest and settlement by European races, is to-day transformed into a land teeming with all the best elements of an advanced civilization. Africa, which long before the time of Columbus had witnessed the rise and fall of an Egyptian race remarkable for its science and its culture, is but now, within the last twenty years, beginning to lose the name of Terra Incognita and to be opened for colonization or for commerce.

The demarcation of territorial lines in America, undertaken in an age when exploration was a novelty and experience was lacking, occupied several centuries. In Africa the partitioning of the continent among the nations of Europe, not seriously attempted until 1880, has taken place on so gigantic a scale that to-day little available land remains; in fact, the recent reconquest of the Sudan by General Kitchener may be considered as the final act in a general European rush for acquisitions. The division has been made, the claims have been filed upon, and the problem of development now presents itself to each of the countries interested. The time is opportune for a general review of the origin, nature and results of this greatest of expansion movements in the world's history.

The recent rush for land in Africa did not begin in earnest until the last quarter of the present century. Up to the year 1875, some few states and colonies, relics of the great Mohammedan conquests of the seventh and eighth centuries, or of early attempts at colonization

by Europeans, fringed the continent, but had no knowledge of or influence in the vast interior districts. Egypt, defeated in her plans of aggrandizement by the interference of European states, had fallen under the joint control of England and France, though still holding a subject relationship to Turkey. Tripoli and Tunis were also nominally dependencies of the Sultan. Algeria, entered by France in 1830, through motives of domestic rather than colonial policy, and finally conquered in 1839, was under French military government. Morocco, an independent Mohammedan sultanate, having no power and of no importance in international affairs, was sullenly waiting, as she still waits, for the day when some progressive state should usurp her government and seize her territories. Scattered along the Guinea Coast were little trading colonies or posts, belonging principally either to England, in Gambia, Sierra Leone, Lagos, and the Gold Coast, or to France, in Senegal and Gaboon. Liberia was an unimportant state, with some 20,000 black citizens, safe from the encroachments of its neighbors, but with no prospect of development. These were but dots of civilization upon the borders of undeveloped barbarism, while even smaller districts were intermittently occupied by Spaniards and Portugese. Farther south stretched the great territory of Angola, claimed, as was Mozambique on the east coast, by Portugal in virtue of early discoveries, but never influenced by any energetic effort toward commercial development. Cape Colony, settled by the Dutch and by French Huguenots, an English possession acquired during the Napoleonic wars, was in a prosperous condition, and was considering an extension of frontier to the north. Many of the Dutch, dissatisfied with English government, had trekked to the northeast, and had there founded the Orange and Transvaal republics. Finally, on the coast north of Mozambique lay the loosely governed country of the sultan of Zanzibar, a Mohammedan potentate, whose power was limited to a narrow fringe of coast-line. (See Map I.)

Such, then, was the very limited occupation of African territory by European states during the first three-quarters of the present century. From 1850 on, interest in Africa slowly but steadily increased. The export of slaves to our western world had almost entirely ceased, but Livingstone and other explorers and missionaries soon made known to the world that that exportation of slaves had been but a drop in the bucket when compared to the enormous and wickedly cruel slave-trade carried on by the Arabs of the interior, and humanitarian sentiment rapidly revived. Interest in exploration increased also. The accounts of men like Burton, Speke, Grant, Baker, Nachtigal, and, more than all, of Stanley, were read widely and eagerly, so that the public was educated to an understanding of the condi-

tions existing in Africa. Inevitably men's thoughts turned to the wonders which had been accomplished in other barbarian territories, and the desire came to do as much for this old, yet new, land. To one man, however, to Leopold, king of Belgium, is due the credit of organizing this public sentiment, of devoting time, energy and money to the furtherance of his ideals, and of attempting, at least in the beginning, to secure the exploitation of Africa on broad humanitarian lines, tending to the preservation of international amity. Leopold, in 1876, was in the prime of life, forty years of age, and had been upon the throne ten years. Belgium, by its separation from Holland in 1830, had forfeited all claim to, or interest in, Dutch colonies then existing. Its territory was limited, its home interests and politics were comparatively trivial, and its territorial position such that its neutrality in time of war had been guaranteed by the other nations. Thus it had neither home nor international politics of sufficient moment to satisfy the ambitious mind of the king, so that the opportunity to become the leader in a modern crusade against barbarism appealed to him with tremendous effect. His resources, however, were limited, and he therefore formed the plan of sending out expeditions backed by an international society, and to this end called a conference at Brussels to discuss the exploration and colonization of Africa. The conference met September 12, 1876, representatives being present from all the European countries. An association was formed, and committees appointed for each country, to solicit subscriptions. The work as outlined by Leopold was to be exploration for humanitarian purposes, and the results, if favorable, to be shared in equally by all nations. National pride in the part taken by their king in this international movement induced Belgian merchants to subscribe largely to the fund, but in other countries the returns were extremely disappointing. Nevertheless in 1877 expeditions were quickly organized which attempted to penetrate Africa from the eastern coast; for it was from this direction, from which nearly all previous expeditions had started, that the best results were expected. These expeditions, badly managed from the first, under the command of Belgian army officers of no previous experience in exploration, were dismal failures, and matters soon came to a standstill. Suddenly, however, the world was startled and interest revived by the unexampled feat performed by Stanley in his journey "across the Dark Continent." Starting from the east coast of Africa, he had struck the head waters of the Congo, and following that river, noting the great natural resources of this heart of Africa, had emerged upon the western shore in the spring of 1878. The news of his success preceded him to Europe, and as he stepped out of the train at Mar-

seilles he was seized upon by Belgian emissaries, who gave him no rest until, some months later, he held a private conference with Leopold and promised to undertake a new expedition to the Congo. This time he was to start from the west coast, to explore the whole basin of the Congo, and to make treaties, if possible, with native chiefs, so as to give the international association the first claim upon this new field for commercial enterprise. The expedition was publicly announced and funds solicited, but Stanley's connection with it was kept secret, and in consequence the money came almost wholly from Belgium itself. Without doubt Leopold already had the plan of merging his international association into a purely Belgian enterprise, and of creating a great Belgian colony in Africa. Soon, indeed, the foreign subscriptions were returned to their donors. Nor can Leopold be blamed for this when the lack of substantial support from other countries is considered.

The reason for the secrecy maintained about Stanley's part in the expedition was the well-founded fear that if Stanley's leadership became known other plans of exploration made in France would be hurried forward, and that the desired territory might be lost. That might makes right is after all an accepted doctrine in the affairs of nations, and it was not to be expected that little Belgium would be permitted to seize the heart of Africa without opposition from some of the greater powers. Stanley went up the Congo in May of 1879. Seven months later, in December of that year, the French explorer de Brazza set out for Gaboon, intending to penetrate Congo territory and secure treaties from native chiefs upon which to base French claims. In part he was successful, for treaties were signed for the territory on the north of the Congo, but upon the Congo itself, and its tributaries, Stanley was in advance and de Brazza could gain no foothold. Portugal too, though not having the money to equip an expedition, announced that the territory of the Congo was within the limits claimed by her by right of discovery in previous centuries. Stanley remained in Africa five years, and by December of 1883 had made over 4000 treaties and established stations as far up as Stanley Falls, some 1400 miles into the territory he came to explore. In one point only was his work a failure, but in that one point lay the possibility of failure for the whole plan of a successful Belgian colony. In his anxiety to precede others on the upper reaches of the river, Stanley had neglected to secure the land at the mouth, and now it was found that France claimed and had stations upon the northern bank for a considerable distance, while Portugal had established herself upon the southern bank. Of what use to Belgium would be a great colony in central Africa if the ingress and egress were in the

control of other nations, who might at any time positively put a stop to commercial development by vexatious regulations and duties? Thus for the time being the great acquisition of the king of Belgium was cut off from the Atlantic.

The year 1880 saw expeditions started from many points on the coast of Africa. The energy of France in the Congo matter precipitated a general scramble for land. England, lagging a little behind the others, saw, as she thought, a chance to block both France and Belgium by signing a treaty with Portugal in February, 1884, recognizing the latter's claim to coast-line and interior between 5° 12′ and 8° south latitude. This would have given to Portugal both banks of the Congo river, the southern third of French Congo, and most of the territory claimed by Belgium. England was, in return, to get concessions on the Zambezi river on the east coast, but her real reason for signing the treaty was to discredit the claims of France and of Belgium. The treaty was unpopular from the first in England, and was met by such a storm of protests from abroad that it was soon withdrawn. Meanwhile the English government had been aroused to the fact that unusual activity in colonial expansion was being manifested by other European powers, and that British interests must be pushed if England was not to be distanced in the race for land. The French were seeking to gain a foothold on the Congo, Leopold of Belgium was holding steadily to his interior state, and Italy was just forming a great expedition for the penetration of Abyssinia. It was to Germany's action, however, that the awakening of England was due. Up to this time the recently formed German empire had made no attempt to acquire colonies, and it was generally considered that the Germans were neither gifted nor interested in colonial enterprise. Bismarck thought otherwise, and determined if possible to secure colonies, with the twofold purpose of widening the market for German manufactures and of increasing the importance of his country in international affairs. The wide expanse of unclaimed territory in Africa gave ample opportunity for this new line of policy, and upon examining the possessions dotting the western coast-line, it was found that no European country had any established right to the great districts of the southwest known as Damara land and Namaqua land, lying between Cape Colony and the southern boundary of Portugese Angola. Both England and her colony at the Cape had entered a vague claim to this land, but save for a small trading and missionary station at Walfish Bay nothing definite had been accomplished either in the way of exploration or of signing treaties with native chiefs. Bismarck proceeded with cautious steps to secure a right to the territory. One

Lüderitz, of Bremen, announced to the Berlin government his intention of establishing a trading post upon this part of the coast, and asked if protection would be guaranteed to him. Bismarck thereupon, in 1883, referred the matter to the British government, with the request that if the coast-line mentioned was under English control protection should be extended to this German citizen. If not, the German government "would do its best to extend to it the same measure of protection which it gives to its subjects in remote parts of the world, but without having the least design to establish any footing in South Africa." The request was not unusual, and for this reason no suspicion was aroused as to Bismarck's real motive, namely, to secure from England a denial of the existence of a protectorate over the land in question. The time was well chosen, for England in 1883 was in the midst of her difficulties in Egypt, and threatened with a renewal of troubles with the Boers of the Transvaal, so that it was not likely that the English government would voluntarily assume further burdens. Lord Granville did not, indeed, disavow a protectorate, but evaded the point by referring to some uncertain claims held by Cape Colony, thus attempting to postpone action. In Germany Lord Granville's failure to make a distinct claim was seized upon as equivalent to a disavowal and Lüderitz was permitted to set out upon his expedition. As quickly as possible he established a factory, made numerous treaties with the natives, and transferred his rights to an incorporated company, which, in turn, with its lands, was guaranteed protection by the German government in April, 1884. There was great anger and excitement both in England and in Cape Colony, but the movement was accomplished and Bismarck was stubborn in maintaining his position, so that in the end England yielded with as good a grace as possible, retaining only her settlement at Walfish Bay.

Germany had proceeded so far with caution, not making clear her objective point until success was assured. Once successful, the mask was thrown aside, and expeditions under Doctor Nachtigal were hurriedly started for the districts as yet unoccupied on the Guinea coast, where a number of German factories had been maintained with profit for a number of years. Portions of this coast were already under the protection of England, and such as were not directly claimed had long been within her influence, or that of the Niger Company. Information of the new German plan brought about a remarkable race between Doctor Nachtigal and the English consul, Mr. Hewitt; a race lasting a year or more, and having for its object the securing of "first treaties" with the natives. In a sense both men won, for the ground to be covered was so extensive that each secured new territory for his country. Consul Hewitt, with the

aid of the Niger Company, filed claims to the region at the mouth of the Niger known as the "Oil Rivers"; while Germany secured a little strip called "Tagoland," east of the English Gold Coast colony, and to the south of the Niger, the larger territory of the Cameroon. So close was the contest that in the first of these German possessions Doctor Nachtigal preceded the English consul by but one day, while in the second he was only five days in advance.

The unexpected weakness shown by England in regard to the west coast is to be explained in part by the difficulties existing in southern and northern Africa. In the south were the two Boer republics, founded originally by those inhabitants of Cape Colony who were dissatisfied with the arbitrary methods used for the abolition of slavery. The independence of these states had been recognized in 1852 and 1854, but, in a war with the Zulus in 1876–'77, the Transvaal having asked for and received aid from England, was practically annexed by that country. The result was the Boer revolution of 1880, in which English soldiers were defeated by Dutch farmers, and the independence of the Transvaal reëstablished. Still the relations between England and Cape Colony on one side and the Transvaal on the other were not satisfactory, and it was not until 1884 that a settlement was reached which again recognized the latter country's independence, restricted, however, by the provision that no treaty or alliance was to be made with a foreign power except upon the approval of the English government. In 1885, influenced by Germany's activity, England announced a protectorate over Bechuanaland, north of Cape Colony.

It was toward Egypt, however, that English attention was chiefly directed at this period. The joint control by France and England had become unsatisfactory because of a lack of harmony between the two governing powers, and the absorption of nearly all the civil and military official positions by foreigners had aroused a feeling of resentment among educated Egyptians. A national movement was started for the expulsion of the foreigners, led by Arabi Pasha, and secretly encouraged by the French and the Khedive, culminating in the rising of 1882 at Alexandria. At the moment when the English fleet was about to open a bombardment of the city, the French fleet sailed silently out of the bay, thus pointedly emphasizing the determination of France to withdraw from Egypt. The desertion of the French fleet did not prevent the English admiral from proceeding with the bombardment of Alexandria, nor did the withdrawal of France from the joint control check England in suppressing the revolt and continuing to govern Egypt. The only result was a more energetic foreign control, but one exercised with a much greater care for the real interests of Egypt and for the feelings of the natives.

A far more serious affair was the appearance in the fall of 1882 of a fanatical Mohammedan in the Egyptian Sudan, who claimed to be the successor of the great prophet, and whose followers were rapidly recruited from that class of the population which had suffered under the burdens imposed by the Egyptian government of the Khedive. Some startling initial victories gave to the Mahdi the prestige of a prophet, and his revolt quickly widened into a plan for a new Mohammedan crusade and the reunion under ancient forms of all Mohammedan nations. The Baggara Arabs, slave-traders of the Sudan, and the best fighters in Africa, joined the Mahdi's forces, and so swelled his army that post after post fell into his hands, until finally in 1885 the last stronghold, Khartoum, with Gordon in command, was captured and the garrison annihilated. The blow was decisive. England reluctantly determined to limit her authority to Egypt proper and leave to the Mahdi the territory he had conquered until time should be given for the training of an effective Egyptian army. Partly in pursuance of a plan for the future reconquest of the Sudan, and with a view to an attack in the rear, English control was shortly proclaimed over the island of Socotra, in the Gulf of Aden, and over a portion of the Somali coast. Although England had withdrawn from the Sudan, the Egyptian claim to that territory was never renounced, it being considered as a district in revolt but still belonging to the mother country. Whatever may have been the theory of temporary occupation proclaimed by English statesmen, the real result of England's control has been the cataloging of Egypt among the list of British African possessions. (See Map II.)

At the time the events in Egypt were not regarded as forming a part of the general movement toward colonial expansion, principally directed toward the western coast of Africa. The contest over the mouth of the Congo, the stubborness of Portugal in still maintaining her great claims, though the support of England had been withdrawn, the uncertainty as to what recognition should be given to the possessions of Leopold of Belgium and the difficulties sure to be encountered if the African enterprises of the European states were not conducted upon some international rules all led to the feeling that a crisis was approaching. Under these circumstances France and Germany began to encourage indirectly the idea of a European congress to consider African affairs, though finally Portugal was the nation to make the direct request for one. The result was the Berlin conference of 1885. The details of its meetings are unnecessary. Called together on November 15, 1884, the general act or treaty resulting was signed by the representatives of all the European powers, except Switzerland, on February 24, 1885. The land claimed by Leopold of

Belgium for his international company was created an independent state under the name of the Congo Free State, with Leopold as its ruler, and thus connected with Belgium in a personal union. Imports were to be free to all nations. Only such duties were to be levied as were necessary to provide for expenditures in the interests of trade. All the rivers were to be free to the flags of all nations. An international navigation commission was instituted to insure facilities of navigation on the Congo and its tributaries. The boundaries of the state were so fixed as to give control of at least one bank of the Congo at its mouth, France in the end ceding a small strip on the northern bank to Portugal, and Portugal in return ceding the southern bank to the Congo Free State. The latter was to be neutral under all circumstances of possible conflict between other African states.

This international agreement resulting in the formation of the Congo Free State was heralded as the dawn of a new era in colonial expansion. The state was to be a great humanitarian agency in the improvement of native conditions in Africa, and the citizens of all European nations were to have equal rights of trade and industry within its borders. In fact, however, this "international" state has become but a Belgian colony, administered directly in the interests of Belgian trade, and controlled almost entirely by Belgian officials. Its development has proceeded with halting steps because of insufficient funds, while its special humanitarian character has been lost sight of in the eagerness to secure an early return on the investment made. There, as in other African colonies, crimes against humanity have now and then been committed, due to the failure on the part of inefficient officials to distinguish between necessary repression and unnecessary oppression of native races.

In regard to general rules for the territorial occupation of Africa the conference did not accomplish as much as had been expected of it. About all that was done was to establish the principle that "occupation on the coast of Africa, in order to be valid, must be effective, and any new occupation on the coast must be formally notified to the signatory powers, for the purpose of enabling them, if need be, to make good any claim of their own." The reason for the failure to do more than this lay in the uncertainty of each of the powers as to just what rules of action would be best suited to the development of its individual plans, and hence a disinclination to bind themselves to any fixed line of conduct. (See Map III.)

From the Berlin conference in 1885 to the year 1898 marks a period unexampled in the race for colonial expansion. The European powers sent out expedition after expedition, signed thousands of treaties with native chiefs, filed claims on vast districts, became embroiled with one

another over these claims, made mutual concessions, and pacifically arranged their disputes. The movement is unlike any other movement in history in the partition of so great a domain in so short a time, and in that it was accomplished without any serious break in the relations of the rival powers. At the end of the thirteen years little remained to be taken. During this time an international conference was held in Brussels in 1890 for the purpose of taking measures for the repression of the slave-trade of the interior, but as it neither marked any change in the progress of events in Africa, nor introduced any new principle of partition, it may be passed over. Our interest lies in noting what each nation secured and some few of the attendant incidents, interesting as indicative of methods pursued. The best idea is to be obtained by taking up the annexations in each general division separately rather than by attempting to follow the movements of each year.

In east Africa the land still "open" to colonization was for the most part under the control of the sultan of Zanzibar, a suzerainty being claimed over the coast-line and the highways of trade with the interior. English influence was predominant with this Mohammedan prince, but the English government hesitated to declare a protectorate over the country, though frequently importuned by the sultan himself to do so. Delay here, as in the case Namaqualand and Damaraland, gave opportunity for a small body of enthusiastic German expansionists to press forward their plans. In 1884, after receiving favorable reports from some preliminary explorations, a German company was organized, and in 1885 Dr. Karl Peters was sent out to sign treaties and annex territory, no attention being paid to the rights of Zanzibar. The expedition was very successful, but English interests were aroused and this time England was determined not to relinquish all rights. Probably little difficulty would have been experienced in reaching a just basis of division had it not been for the enterprise of Doctor Peters in pushing inland toward the head waters of the Nile. This portion of Africa lay within the limits of the territory which England intended to secure by a reconquest of the Sudan. In 1887 Stanley had started from the mouth of the Congo for the "relief" of Emin Pasha, a German formerly in the employ of the Egyptian government, and in effect another race took place between England and Germany, with Stanley and Peters as the agents. At the same time other English expeditions were started from the east coast. Stanley succeeded in getting Emin Pasha out of Wadlai, and English treaties with natives were signed before Peters could obtain a foothold, but the contest might have grown to serious proportions had it not been for a native uprising which demanded a joint suppression by the

two countries. This paved the way for an agreement in 1890 by which England maintained her hold upon the sources of the Nile, while Germany acquired territory stretching to the Congo Free State on the west and including a shore line on both lakes Victoria and Tanganyika. German East Africa is placed as a wedge between British territory in north and south Africa, thus effectually blocking any plan for continuous British possessions from Cairo to the Cape. In the meantime Emin Pasha entered the employ of Germany, and, returning to the interior, was murdered there in 1892 by some Arab slave-traders.

Italy had marked out for her own the country lying north of British East Africa, though, by the Anglo-Italian agreement of 1894, English supremacy was established on the Somali coast from the French station at Obok eastward along the Gulf of Aden. France, too, had extended her Obok station some 200 miles back from the coast. With these exceptions Italy was given a free hand to do what she could with the rest of Somaliland and Abyssinia, and devoted most of her energy to the latter country. There was need of energy, for Abyssinia was under the control of a powerful native prince, one likely to give more difficulty than had been experienced from the other so-called native princes of Africa. Abyssinia is as yet comparatively unknown land. Its people are distinct from those of other parts of Africa, its religion bears some resemblance to that of the Greek Christian church, and the pride of its ruler is such as to render unlikely any acceptance of a "protectorate" from a foreign power. Italy succeeded, however, in securing a protectorate treaty, upon which she based a claim to Abyssinia, and her rights were recognized by the nations of Europe. Expeditions by other countries discovered that the negus of Abyssinia thought that in signing the treaty he was guaranteeing protection to Italy, rather than accepting it from that country. It was not long before this misunderstanding led to war in 1896. Menelek's well organized forces utterly defeated the Italian troops, with the result that at present Italy has but a weak hold upon a narrow strip of coast-line.

In western Africa interest was centered at first in the development of the Guinea coast and in the land lying along the Niger. This river is navigable for a greater distance from the ocean than any other waterway in Africa, offering no serious obstruction to boats up to 300 miles from its mouth, while the country through which it flows is rich in natural products. Stations upon the Guinea coast had been established in earlier centuries, but the climate is deadly for white men, and many colonies had been withdrawn or had died out, so that little real progress was made until recent years. The principal nations contending for the mastery here were France, England,

and Germany, each of which already had small establishments at a number of points. France, at various dates from 1880 on, sent in exploring military expeditions, using as bases Algeria on the north, Senegal on the west, and the Ivory Coast colony on the south, with the object of so extending territory from each base as to unite in one solid block the hinterland of these colonies. The point fixed upon as the goal was the famous city of Timbuktu, on the upper Niger, a city then supposed to contain at least 100,000 souls, and to be of great importance as a trade center. The expeditions southward from Algeria were largely failures, owing to the intense hostility of the tribes inhabiting the Sahara, but those from the west and south pushed steadily forward, reaching Timbuktu in 1893. The city itself was a disappointment, having only 10,000 population, and being of little value as a trade center, but the purpose of connecting the various colonies was practically accomplished, French Congo being the only district occupying an isolated position. There was a possibility of bringing even this in touch if France could occupy before her rivals the region southwest of Lake Chad. Both England and Germany, however, were rapidly pushing to the interior. England, operating through the Royal Niger Company, preëmpted the lower reaches of the Niger and its tributaries toward the northwest, while to the northeast a "zone of influence" was claimed about all the shores of Lake Chad. Germany forced back the base of her wedge-shaped colony of Cameroon. Thus the French seemed doomed to disappointment in this last plan for uniting their colonies. By 1893 delimitation treaties had become necessary to determine the exact position of each of the powers. England, because of the weakness of her pretensions to the Lake Chad district, was compelled to yield somewhat to both France and Germany, the former country reaching the northern and the latter the southern shore of the lake, while England occupied the middle position. Probably one reason for the agreement with Germany was the idea of English statesmen that French Congo would be all the more effectually cut off if Germany were made a partner in the game. Germany had no sooner secured the land in question than she gave up half of it in 1894 to an extension of French Congo to the lake, so that after all France realized what had seemed impossible.

In 1886 Spain announced a protectorate over a block of some 200,000 square miles of land in the western Sahara, though both Morocco and France profess to have counter rights. With the exception of this district, of the English Niger protectorate, and of the German Cameroon, the bulk of northwest Africa is French territory. The main characteristic of French colonization has been conquest by military expeditions, with little successful attempt to build up trade or

settlements, so that while France has the land the question of what is to be done with it is as yet unsettled. Liberia and the small English colonies in Gambia, Sierra Leone and Gold Coast are cut off from the interior by French Sudan, while the same condition exists for French Dahomey and German Tagoland in their relation to the English Niger protectorate.

In South Africa, Great Britain is practically the sole nation concerned, for Portugal has done nothing in the way of development. In 1891, in fact, she was compelled to cede to English interests a valuable bit of land in the interior, and negotiations are said to be even now under way for the granting of still further concessions. The great organizer of the English movement northwards from Cape Colony is Cecil Rhodes, who is working for the federation of all South African states under the protection of Great Britain. Under his influence the British South African Company was chartered in 1889, receiving almost complete governing power over Matabeleland, with liberty to control mining industries and rights, land grants to colonists, and to make laws for the regulation of the territory, but subject to a withdrawal of its charter at any time by act of parliament. Its rights are of course founded upon treaties with native chiefs, the principal one having been signed with Lobengula, chief of the Matabeles, in 1888. In spite of some native risings in 1893 and 1896, the company's control has been steadily and effectively exercised, and many flourishing towns have been established by English colonists. As an essential tool for the furtherance of his ideas, Rhodes has pushed forward the plan of a transcontinental railway and telegraph line from "Cairo to the Cape." The telegraph line is largely the result of personal financial investment by Rhodes and his friends, and has already reached Salisbury, a distance of 1700 miles from the Cape. It is almost certain to be completed in the near future. For the railway, government assistance is asked in the shape of a guaranty of interest on construction debt, and Rhodes was recently in London urging the acceptance of this plan, though the execution of the project must necessarily proceed with deliberation. The position of premier of Cape Colony, formerly held by Rhodes, was of material assistance in forwarding these great plans of empire building, but the unfortunate results of Jameson's raid for the relief of the inhabitants of Johannesburg, in the Transvaal, the details of which are not essential to this review, caused a loss of influence and position in Cape Colony politics. While Rhodes was not found to be directly responsible for Dr. Jameson's acts, the ill feeling between the Dutch and foreigners in the Transvaal, and the sympathy of the Dutch in Cape Colony for their kinsmen in the neighbor state, have contributed much to

Rhodes's loss of ascendancy. Still he is steadily regaining his influence and is undoubtedly the foremost figure in South African affairs. Little doubt is expressed that his favorite federation scheme will be realized at no very distant date, though stirring times may be experienced before the Transvaal consents to enter the combination.

North of the Zambesi the English government has declared a protectorate, to the southwest boundary of German East Africa. Great returns are expected from Mashonaland when modern methods in mining shall be applied to the numerous ancient gold- and silver-mines worked to water-level by some unknown early peoples. This land also is to be included in the general federation of South Africa.

After the fall of Khartoum in 1885, and the English withdrawal from the Sudan, the affairs of Egypt proper were administered with the purpose of gradually preparing the native government and army for an attempt at reconquest. This has not been done at the expense of other interests, for the administration has been greatly improved in all departments of government, and the work of Lord Cromer and his assistants will stand as one of the greatest achievements of the English race in the wise development of a protected nation's resources. One of the chief causes of the Mahdi's rapid successes was the inefficiency of the native Egyptian soldiers when brought face to face with the fierce warriors of the Sudan. To remedy this English petty officers have been assiduously devoting their time to a reconstruction of the nation's army, the intention being to have Egyptians constitute the bulk of the army of reconquest, with a sprinkling of British soldiers. The result is to be seen in the recent victorious campaign of General Kitchener, during which Egyptian troops showed no signs of faltering in the presence of the enemy. This campaign was sure to be undertaken sometime, but it was probably hastened by the evident desire of France to get a foothold on the upper Nile. A French expedition was started across Africa from the west, through Wadlai, and a corresponding extension of French territory was feared, but this plan was partly blocked by a lease of territory on the west of the Nile, granted by England to the Congo Free State. Then it became known that French expeditions were to be sent out, which, if successful, would strike the Nile near the town of Fashoda, while at the same time French activity was greatly increased at Obok on the east, military stations being established up to about 200 miles from the coast. England regarded the Sudan as territory in revolt, and held that Egypt's right there must be recognized, but if France could have secured posts in the country before any movement for reconquest took place, it is doubtful whether English claims would have been justified to territory so long independ-

ent. The time had come, therefore, for the forward movement. In 1896–'97, after ten years of rest, Egypt prepared to do battle again with the Arabs of the interior. In the meantime the Mahdi had died, and the khalifa who succeeded him was neither so great a leader nor did he hold the sole power in government, for the Baggara Arabs had usurped authority. Their oppression of the native Sudanese, the original revolutionists, had resulted in the creation of a considerable party ready to welcome the restoration of Egyptian control, though none dared to express this opinion openly. Kitchener's army of invasion advanced steadily up the Nile in 1896, until Dongola was occupied. From this point as a base a second campaign was undertaken in 1897–'98 for the capture of Omdurman, the new capital city, situated near Khartoum, and on the opposite bank of the Nile. The Egyptian troops, with the coöperation of their British fellow soldiers, proved equal to the emergency. In a great battle the Arab army was almost annihilated, and while scattered detachments are still being encountered, the reconquest of the Sudan has practically been accomplished. That England was justified in her suspicions of France was demonstrated by the startling discovery that just previous to the final battle a small French exploring force, from French Congo, had reached Fashoda and hoisted the French flag. For a time there seemed to be a possibility of war between the two nations, but ultimately France gave way and ordered the withdrawal of the expedition, so that to-day uninterrupted communication is secured between Cairo and Lake Victoria. Whatever may be the fiction of government, Egypt is in reality an English protectorate. England's position here and in British East Africa guarantee to her the control of the entire Nile valley from source to mouth. And, indeed, if confidence is to be placed in the speech of Lord Salisbury upon the opening of parliament in February last, the Sudan is now likely to be regarded not as Egyptian territory but as a direct British possession by right of conquest. (See Map IV.)

Such, then, has been the result of the race for colonies in Africa. Comparatively little remains to be taken, and that little a district which is so hostile that it cannot be occupied by the methods ordinarily pursued, but must either be conquered by the sword, or won by substantial privileges and immunities. And yet, in all the vast territories partitioned among the powers, almost nothing has been done in the way of real settlement. It is still an open question whether any actual colonization is possible. It is not pertinent to this review to make any extended examination of those conditions of climate, soil, tropical situation, altitude and contour of coast which will determine in large degree the future of Africa. In general it may be

said, that the dictum of those entitled to express an opinion is that, save in some favored regions, colonization by whites is impossible; that at the best the whites can merely act as organizers of industry among native peoples, and that Africa will never serve, therefore, as a home to which the nations of Europe can send any large part of their crowded populations. There remains, then, only the possibility of so developing native races as to create among them a market for European manufactures, and as a result an increased and organized production, by the natives themselves, of such commodities as Africa affords.

All rules have their exceptions, and in this case an exception as to suitability for colonization must be made in favor of English possessions in South Africa. The short time which has elapsed since Matabeleland and Mashonaland have been open to settlement renders colonization there as yet an experiment. Still everything seems to point to its feasibility. And in general English possessions, occupying as most of them do the high table-land from the Cape to Lake Tanganyika, are most favorably situated. Conditions here differ little from those obtaining in Cape Colony or Natal, where successful colonization has long been a reality. English territory in Africa is greater than that of any other power, the nearest rival being France, with some three million square miles of land, two-thirds of which is desert. Although the Niger district can never serve as a home for Europeans, nor British East Africa in all probability, still the lands acquired by Great Britain offer greater possibilities to the colonist, and thus in the end to the trader, than do the combined holdings of all the other European nations. In other aspects also England has the advantage. The government has a wider experience in successful colonial enterprise than has that of any other power; and more than all, her people have shown themselves gifted in the qualities of adventure and adaptability to a degree not seemingly possible to other nationalities. To one who judges the future by the past, and who notes the potential qualities of the lands in Africa held by the European states, the evidence is conclusive that upon the English government and the English people depends the future of Africa.

The map of Africa has practically been completed, and that, too, without a war, and without serious enmities being engendered. Will a new map be necessary or will the present boundaries be lasting? Without a shadow of doubt, this great partition of a continent, this national run for a homestead, will prove but an ephemeral affair after all. Only on the supposition that wars are at an end, that peace now and forever has settled upon the face of the earth, is it possible to believe that great and mighty exchanges of territory will not take place in Africa. That war in Europe must come sometime, at least

between certain countries, possibly for all Europe, no one who understands political and social conditions there can hesitate to affirm. And when that war does come, the African colonies will quite naturally be used as convenient articles of exchange between the victor and the vanquished. Up to the present, indeed, there is more of interest in the partition of Africa to the student of contemporaneous history than to the sociologist or the philanthropist.

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This review was written previous to the outbreak of war between England and the Boer republics. Instead of a conflict between powers contending for colonial benefits, the unexpected spectacle is presented of a conflict between a sovereign and a subject state. The world believes that, barring international complications, there can be but one result, namely, that British success, at any cost, is a foregone conclusion, and that war will bring into reality a British South African empire which years, perhaps decades, of peace would fail to develop. The merits of the question at issue are foreign to this paper, yet it is impossible to refrain from noting some of their less evident bearings. The present contest was unjustly forced by England. A vague suzerainty over Transvaal international relations afforded no shadow of an excuse for England's interference in the domestic affairs of that republic. Sordid interests were the great moving influences which forced an unwilling nation (for the heart of the British people is not in this war) to indulge in a war of spoliation. The conflict was in no sense necessary to maintain England's colonial supremacy, or to insure the fulfilment of her destiny as the great civilizing agent in Africa. But setting aside the question of abstract justice, and turning to the more practical discussion of results, the demand for British victory, now that war is actually on, is, in the spirit of the times, a cry for progress. Granted all the admirable characteristics of the Boer — his courage, steadfastness, loyalty, simplicity, the fact remains that he is two hundred years behind the times; that his cause, in spite of its justice, is the cause of the unenlightened of two centuries ago. Should the Boer win, the general advance of civilization would be materially checked, British influence in South Africa would be seriously crippled, and it is in England's uplifting influence that the hope of Africa lies.

TAXATION IN KANSAS.—Part II.

BY F. W. BLACKMAR.

CONSIDERING the two main phases of the general-property tax, those of personal property and real estate, or movable and immovable, as they are termed in the old world, perhaps the greatest irregularity comes in the attempt to correctly assess this personal property. One of the standard arguments against the income tax is its difficulty of assessment. But there is no evidence of any income tax that ever has been established anywhere in the world exceeding the irregularity of assessment now credited to the assessment of the personal-property tax in the United States. In a new country, before the land has come into cultivation, its value is merely nominal, and the people who come to cultivate it first carry with them an amount of personal property or capital which sometimes exceeds the value of the land. After land is once thoroughly in cultivation the development of mining, manufacturing and various industries tends to increase the personal property in proportion to the land. So, in the past fifty years, in the older states in the union, the actual value of personal property, as property is valued, has increased more rapidly than the value of the land. Yet, as was shown by table I, part I, this is just reversed in the actual valuation made by the assessors.

There can be only one solution to this question, and this is that personal property, being so intangible that it is not returned, cannot be satisfactorily taxed. As a rule people do not like to pay taxes, because it is not like any other investment. They do not see an immediate and equivalent return for the money expended. The second proposition that is affecting us worse than any other is the tendency for each one to feel that he is paying more than his share. We have no standard of assessment to-day which is of any practical value; therefore, having departed from a standard, everything is irregular.

Consider that everybody is honest in making his returns. He is asked to give in his property and the assessor is sworn to return the property at its market value. Now, who can tell the market value of an old piano, of old furniture and carpets? or who can tell the market value of paintings, or of books or apparatus of any kind? These things in most towns are not bought and sold on a real market valuation. Really there is no legitimate market for second-hand goods. There is a process of disposing of them on the basis of getting what

you can. Therefore, in real honesty, it is almost impossible to assess certain forms of personal property.

When people wish to be dishonest it is an easy matter to hide away jewelry and stocks, bonds, and things of that nature, and thus escape taxation. It is said that notwithstanding the increase of population in Philadelphia there are fewer watches used there every year. Investigation in the city of Chicago shows some of the most glaring irregularities in returns. It is a notorious fact that the assessors, as a rule, go into office poor men and come out rich men. It is asserted on good authority that one agent and an assessor can divide the spoils and allow the property owner to escape a large amount of the assessment.

But the inequalities of the assessment and collection of the tax on personal property is no new subject and every one is conversant with the irregularities that exist. I know men with considerable personal property in sight, living in luxurious homes, in Kansas, who estimate the value of their personal property at a small amount and then subtract the $200 exemption, which leaves little or nothing to pay.

But glaring as these irregularities are, we find equally as bad discrepancies in the assessment and taxation of real estate in Kansas, although they arise in a different way. These irregularities come chiefly from imperfect methods of assessment, notably in three specific ways previously mentioned in part I: First, the rivalries of counties to pay the least amount possible of the state tax; second, the rivalries of townships and towns within the county to scale down the assessment; third, the rivalry of individuals to shift the burden of taxation upon others. These irregularities continue in spite of the fact that the law of Kansas is very specific in stating that the assessor shall return all property at its full market value.

An investigation into the tax returns from a large number of the counties of the state shows that property is valued at ten to eighty per cent. lower than required by law. It has been shown that in very few of the counties did the assessors agree, before making the assessment, to obey the law to its fullest extent. In Rawlins and Decatur counties the basis of assessment was 100 per cent. on both real and personal property. In Thomas, Greeley, Stanton, Hodgeman and Wichita counties the assessors agreed to assess all real estate at 100 per cent. of its true value, while the personal property was thought to be worth for taxation purposes only 33⅓ to 90 per cent. In Gove, Gray and Grant counties the assessors decided that to get sufficient revenue from real estate they must assess all such property at twice its real value. The counties named, it will be noticed, are situated in the western third of the state. In the eastern two-thirds the agreed basis ranged from 20 to 50 per cent., averaging about 33⅓.

Despite the "agreed basis" the actual assessments did not follow the agreement. The variations in 1897 showed, by the actual sale of property in thirty different counties, that the average assessments range from 15.9 per cent. of true value in Atchison county to 51.5 per cent. in Barber county, while the taxes upon this property ranged from one-half of one per cent. in Butler and Wabaunsee counties to 1.6 per cent. in Comanche county. The assessment of town lots shows a greater variation, ranging from 19 per cent. of true value in Wabaunsee county to 75.4 per cent. in Hamilton county. The taxes varied from nine-tenths of one per cent. in Wabaunsee county to 4.1 per cent. in Ness county. It is interesting to note that before this irregular assessment takes place the assessors, who must be sworn to assess property at its market value, have no notion of fulfilling the law. The only question is, what part of the law will they obey; whether it will be one-fifth, one-fourth, one-third, or a half. The following table shows the agreed basis and the actual basis of assessment in seventeen counties. It may be noticed that in general those counties having a low agreed basis were really assessed somewhat higher than that, while in those counties which had a high agreed basis the actual assessment was somewhat lower.

County.	Agreed basis.	Actual basis.
Atchison	25	15.9
Bourbon	20	32.8
Brown	20	20.2
Ford	50	33.6
Franklin	50	29.2
Gove	200	30
Lane	100	33.7
Leavenworth	33⅓	31.7
Mitchell	40	42.1
Neosho	33⅓	33
Republic	20	21
Russell	33⅓	36.4
Riley	33⅓	28.7
Sedgwick	30	41
Shawnee	33⅓	40
Wabaunsee	20	26
Wyandotte	33⅓	24.2

There are other irregularities, caused by the fact that each board of township assessors has a different schedule. Some especially grade live stock and others do not; some grade corn and wheat and others do not; and some profess to assess all property at full value, but when it comes to the assessment they fail to do so.

Now as to the discrepancy within the county, there is still the same jealousy, though to a less degree, between towns and townships and

between the various townships themselves, each one seeking to avoid paying more than its share of the taxation. A great inequality of assessment is noticed in individual cases. The difference between the maximum and minimum per cent. of assessed valuation and the actual selling value is the greatest in Ellsworth county, with a minimum of 17.7 per cent. and a maximum of 720 per cent.; while the least difference occurs in Wyandotte county, where the minimum is 3.7 and the maximum 34 per cent.

But more baneful still is the discrepancy observed between the various individuals, as marked by groups of large and small holdings. It is found, in nearly every instance, that the small farm pays a larger proportion of the taxes than the large farm. Take several groups of land ranging in selling value from under $250 to over $10,000: group one, under $250; group two, between $250 and $500; group three, $500 to $1000; group four, from $1000 to $2500; group five, from $2500 to $5000; group six, from $5000 to $10,000; group seven, all over $10,000. Now, it is an actual fact that some of these smaller tracts, in some counties, are assessed at two or three times their selling value, while the larger farms are assessed at one-fourth their selling value. The average assessment in group one is 107 per cent. of its value; in group two, 50 per cent.; in group three, 41 per cent.; in group four, about 30 per cent.; in group five, about 25 per cent.; in group six, about 18 per cent.; in group seven, between 16 and 17 per cent. of true selling value. This discrepancy is, of course, a great injustice to small holders.

Nor is this irregularity confined alone to so-called personal property or land. A short time ago a great packing-house burned which was said to be worth considerable money. Its assessed valuation was $50,000. After the fire it was found that it was insured for $900,000, eighteen times the assessed valuation. Now I am not going to say where this irregularity existed, whether it was in the insurance companies or in the assessment. At any rate it is a discrepancy that ought not to exist if we hope to see justice of taxation and contentment among the people. By a comparison of the assessed valuation of the capital invested in large manufacturing concerns such as packing-houses and mining companies, and that of smaller firms such as cigar factories and printing shops, it has been noted that the larger business, the one best able to pay a heavier rate because of the increased power of combined capital, pays from one-half to one-third the amount of the smaller firms in proportion to their capital. It may be because the assessor feels somewhat ashamed to return an assessment of one-third of a $2000 business, and thus increases the relative assessment; it may be because of the fear of the large property

owner on the part of the assessor; or it may be because of a direct bribe.

The variation between the real value and the assessed value of property is more marked each year. In 1890 the federal census gave the estimated real value of all property in Kansas as $1,800,000,000, while the assessed value of the property in the same year was $348,000,000, or about 19 per cent. of the true value. The assessment of property in 1898 would seem to indicate that the difference between the assessed value of property and its real value is even greater, the former being about 15 per cent. of the latter. There has been a steady decline in assessed values in respect to real values. In 1870 property was assessed at 50 per cent. of its real value; in 1880, 21 per cent.; in 1890, 19 per cent.; in 1898, 15 per cent. In 1890 there was a wide discrepancy between the assessment of railroad property, real estate, and personal property. The estimated real value of railroad property was $462,000,000, while its assessed valuation was about 13 per cent. of this; the estimated real value of personal property was $364,000,000 and its assessed valuation fixed at 13½ per cent., or $48,750,000; the true value of real estate for the same year was $940,000,000 and its assessed valuation about 26 per cent. of this, or $241,000,000. Since 1890 the assessment has fallen rapidly on real estate and considerable on personal property, while railroad assessments have kept up the best of all.

I must refer briefly to the taxation of corporations. The corporation is a comparatively new object of taxation. In our attempts to tax their property in the various forms we have shown little knowledge of their character. First, the states paid no attention to them and went on with the general property tax; next, they concluded that they were persons and should be treated as other persons; and finally they concluded that they were different from other persons and should receive special treatment, and every state in the union began a different treatment of the various corporations. They taxed them on the value of the property, that is, the real estate plus the visible and the invisible personal property; they taxed them on the cost of property; they taxed them on the capital stock at its par value; on capital stock at its market value; on capital stock plus bonded debt at its market value; on capital stock plus total debt, both funded and floating; on capital stock according to dividends; on business transacted; on net earnings; on gross earnings; on bonded debt; on loans; and finally on franchises; and, in the case of railroads, on mileage.

In all of these various changes of taxation, legislators have failed to notice one great principle, the incidence of taxation. It answers

the question, Upon whom does the tax ultimately fall? It is generally considered that a tariff or an excise tax will fall upon the consumer, but this is not always true; there are many cases in which it can be shifted. It is generally supposed that the income tax is a direct tax and will fall upon the one who has the benefit of the income; but in the United States, where we have little pure income, where it is mixed with profits and wages and property of various sorts, an income tax might be partially shifted. It would seem that cash in the bank could not avoid taxation, yet it is strange that it gets out of the bank before the 1st day of March and gets back again afterwards. The tax on mortgages was supposed to lay a burden on the capitalist who loaned the money, but when tried in California the burden fell upon the borrower in an increased rate of interest. The tax on wages does not always come out of the wage-earner; if he has a low standard of life you cannot take anything more out of him without taking from the employer.

A short time ago we taxed the express companies and the telegraph companies; but the other day I sent a message, and the man said, "One cent, if you please." I said, "Why?" "For tax," he replied. "But," I said, "that is your tax." "Yes, but you will have to pay it." And so I had either to pay it or else not send the message. I could not afford to sue the telegraph company for a cent. I went into the express company's office and they said the same thing to me, "A cent." Thus the incidence of these taxes was not where it was laid.

Now, in the taxation of corporations this principle of the incidence of taxation should be carefully observed; for not only is there danger of the tax being shifted, but there is danger of doing injustice to the corporations themselves by instituting double taxation. Indeed, I do not know that I ought to accuse anybody of irregularity in dodging taxes, so long as we allow such irregular systems to prevail in their assessment. There are at least five ways in which double taxation arises with relation to corporations. If you tax property and debts, or income and interest or debts, there is danger of double taxation; also in the taxation of property and income and property and stock; and also from the conflicts of jurisdiction of different states in the taxation of corporations; and also the holders of stocks or bonds. It is very difficult to get a tax on corporations which will really prevent the danger of double taxation and yet reach all forms of property; but, in the first place, we must consider corporations as different from individuals and reach their property in a different way. There are some things, however, which ought not be done in the taxation of corporations. Wherever the corporate stock or property is taxed the shareholder should be exempt; or if corporate loans are taxed the

bondholder ought not to pay a tax; and if corporations are taxed on their capital stock they should not be taxed again on property which this capital stock represents. If real estate is to be taxed, it should be done locally and not generally.

The tax on earnings or on capital and loans is a fair way of reaching the property, although it should be on gross earnings and not on net earnings; otherwise there will be no net earnings. When, in the taxation of corporations, real capital or loans are taxed it should make no difference where the shareholder or bondholder resides, and likewise no discrimination should be made between foreign corporations and domestic corporations. The state, in the taxation of corporations, as in the taxation of land, should be limited to the boundaries of the state; and if the shareholder or bondholder reside in different states from the corporation, there should be some interstate agreement for the regulation of the share of taxes. Wherever corporations have a special monopolistic privilege granted to them by the people there should be a franchise tax, regulated on the importance of the enterprise as a whole, or on its annual earning capacity. If the taxation of corporations should be met by an assessment on income, except in case of special public franchises, it would doubtless be as safe and equitable a method as could be established. But there arises a difficulty in reaching that income; for, if taxed on net earnings, the gross earnings may be so distributed in improvement as to leave little; and if gross earnings be taxed, there is an opportunity for holding too large an amount of unproductive property for speculative purposes which receives no tax at all.

THE NEW ZEALAND LAND-AND-INCOME TAX.

Perhaps the most unique taxation is that of New Zealand, where, so far as it has been tried, it seems to meet fairly well the difficulties under which we are now laboring. In the year 1891 the government of New Zealand abolished the general property tax and instituted therefor a land-and-income tax, which, though separate in form, work harmoniously together. The land tax is levied on the unimproved value of the land. The owner of the land is required to make returns of all mortgages held on his property by others and all similar mortgages held by him on other lands. He is allowed to deduct the amount of all registered mortgages from the valuation of the land; the mortgagees are called upon to pay the tax upon the sum total of their mortgages. The owner is allowed £500 exemption if the value of the land, after deducting mortgages due by him, does not exceed £1500, but the amount of exemption diminishes gradually, and finally disappears when the assessed unimproved valuation, after deductions, amounts to £2500. These exemptions greatly reduce the number of

land-tax payers relative to the number of landowners, the former being about 13,000 while the latter number 90,000.

In addition to this ordinary land tax, there is another graduated land tax on all assessed valuations of £5000 and over. Mortgages are not chargeable with the graduated tax nor can they be deducted, this privilege being given to the ordinary tax. This graduated tax, beginning with one-eighth of a penny in the pound sterling on land values of £5000, gradually advances through sixteen grades to £210,000 valuation and above, where the tax is fixed at a maximum limit of "two pence in the pound." The ordinary land tax at present is "one penny in the pound sterling." The graduated tax is in every instance in addition to the uniform land tax. Another form of the land tax appears in the taxation of absentee landowners twenty per cent. additional graduated tax if they have been out of the state three years prior to the passage of the annual tax act.

Formerly triennial assessments were made, but this law has been abolished, all valuations being calculated upon the last assessment, except that on demand an owner may call for the assessment of his property not later than the 31st day of March in each year, and the land commissioner may make an assessment of land at any time he may choose. All assessments are subject to the right of objection and review. If the owner is dissatisfied with the assessment value placed upon his land, he may call upon the assessor to reduce the valuation to the figure given in the owner's return or compel the commissioner to purchase the land at the valuation by the assessor. On the other hand, if the commissioner is of the opinion that land has been undervalued, he may call upon the owner to agree to a higher valuation. Should the owner refuse to do so, then the commissioner may, with the approval of the government, purchase the land at an advance of ten per cent. over the owner's valuation. These methods of assessment are somewhat novel, and one cannot help conjecture as to the results of such a flexible system. The fall in the price of produce in 1893 and 1894 caused many objections to the valuation, and this caused much attention to be given to the readjustment of the assessment, but probably this did not cost as much as a regular assessment of land.

In connection with the land tax is the income tax raised on all incomes excepting those upon land. There is a statutory exemption of £300, together with life-insurance premiums up to £50. All incomes between £300 and £1000 pay a tax of six pence in the pound, or two and one-half per cent.; all incomes over £1000 pay a tax of one shilling in the pound, or five per cent. Thus, an income of £2500 would pay a tax of two and one-half per cent. on £1000, five per cent. on

£1200, and the remaining £300 would be exempt from taxation. Corporations and individuals are taxed, the former on their net profits, and the latter on income from business, wages, or salary.

Such, in brief, is the present tax system in New Zealand, and we have only to add a partial and decayed excise and impost tax to complete the system. The last report at command was in 1895, which showed a general satisfaction over the new system. Most persons appear to think that the taxes are raised more easily and more justly than under the old property tax. The amount of the tax raised has increased a little, which would seem to be favorable to the system. If an income tax is to be used at all, it would seem more sensible to use it in connection with the land tax than in any other way. The advocates of the single tax have hailed this tax reform in New Zealand as a triumph of their principles. The only way in which it approaches a verification of their doctrine is in the tax on land values; that is, a tax on the land estimated upon the capitalization of its net return. Aside from this it is difficult to see wherein lies their cause for rejoicing. It is demonstrated in New Zealand, at least, that a land tax of this nature, supplemented by an income tax, is sufficient to raise the revenue needed, and that it can be determined in a tolerably easy and just manner.

* * * * *

A rational system of taxation and revenue would require a reform in many directions. It would imply, first, a better use of public funds, which would greatly reduce the estimated needs of a community or else realize to the public a larger return of public good for the money expended. The beginning of this and other economic reforms is in economy of consumption, which does not necessarily mean smaller consumption. The method of estimating the public needs before levying the tax makes taxation to hinge primarily upon the settlement of what are public needs. The wants of a community like the wants of an individual are never satisfied. Increasing and enlarged desires are the characteristics of modern civil progress. Is there no way to determine how much tax shall be raised? There is no limit to what a state may do for the people, provided it be for the general well-being of the community. There is no way of determining this well-being except by estimating in a crude way whether there is an economic return for the money expended. The state coöperates with the individual in production. The government is agent for the people in the expenditure of their funds. Is the principal returned to them with a moderate interest in increased means of protection, production, and an adequate well-being and happiness? These are questions that every legislator should ask himself before he introduces

a bill for the expenditure of money. How many of the thousands of bills introduced every year will stand that test? A great many bills have good in them but would not return to the people a service equivalent to one-half the expenditure.

If the present system of taxation is to go on, there must be a reform in methods of assessment. In order that there may be a standard, property should be estimated at its full market value. Great care should be taken to find out what this market value is. In the case of real estate, assessments should not occur as often as heretofore. Once in every five years would be often enough. At such times a great deal of labor and care should be taken to assess the property well. There should be none of the hustling around the country, according to the method of modern assessors, to get the property all assessed in a certain time. Whether we should go so far as the New Zealand system and have a commissioner to change the assessment is a question. I fear we should grow into dangerous abuses of privileges in a country where our assessors have not the best reputation for walking in a straight line.

Again, the township system of assessment should be abolished. No unit should be recognized smaller than the county, and the assessments when once made should be published immediately in some county newspaper, so that every one could know what his assessment is and everything would be done openly. This publication should be done before the meeting of the board of equalization, and then the changes of the board of equalization should be published in a similar manner. In order to stop the rivalry between counties there should be an entire separation of state and county taxation. For instance, in Kansas there is a board of railroad assessors who might be made a board of state assessors to assess general property for a state fund. There is sufficient railroad property to supply all needs in this way. What is needed over and above the support of the state could be apportioned to the different counties in proportion to population. This would be a method also of equalization of state government.

The township method of assessing school taxes is especially vicious, inasmuch as the condition of the school in a district depends not so much on the population of school children as upon the assessed valuation of property. In California they have a system of distribution of state funds which has worked admirably in building up country schools. Each school district receives $500 from state apportionment, and after that a *pro rata* of the remaining funds in proportion to the number of pupils of school age in the district.

There should be a state board of assessors that could be a board of equalization for equalizing the assessments of different counties, with

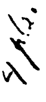
the power to call together the assessors of the counties when desired, and power to visit each county and inquire into the methods of taxation, market value of property, and assessed valuation, in order to ascertain whether just and equitable assessment is being carried on. By some such system there might be a great improvement in the present irregular methods.

If states could be induced to adopt the same method and thus establish uniformity great gain would also be made in this way, but this could only be done by interstate convention for the presentation of plans for the states to adopt. But I advocate the simplification of our methods. Fundamentally I believe in the abolition of the personal-property tax, as it is too bad to admit of any reform. In order that injustice may not be done, great care will need be exercised to reach certain kinds of property, mostly corporate, in some other way; otherwise too heavy a burden will fall upon real estate. I also advocate to go even a step farther and abolish the tax on all improvements. This must be done by degrees, beginning first with farm property, town residence property, and finally business property. The reason for advocating this is that it will stimulate industry of all kinds and call into use vacant land. This will enhance its value and thus make up for the loss in the increased ability of real estate to bear an extra burden.

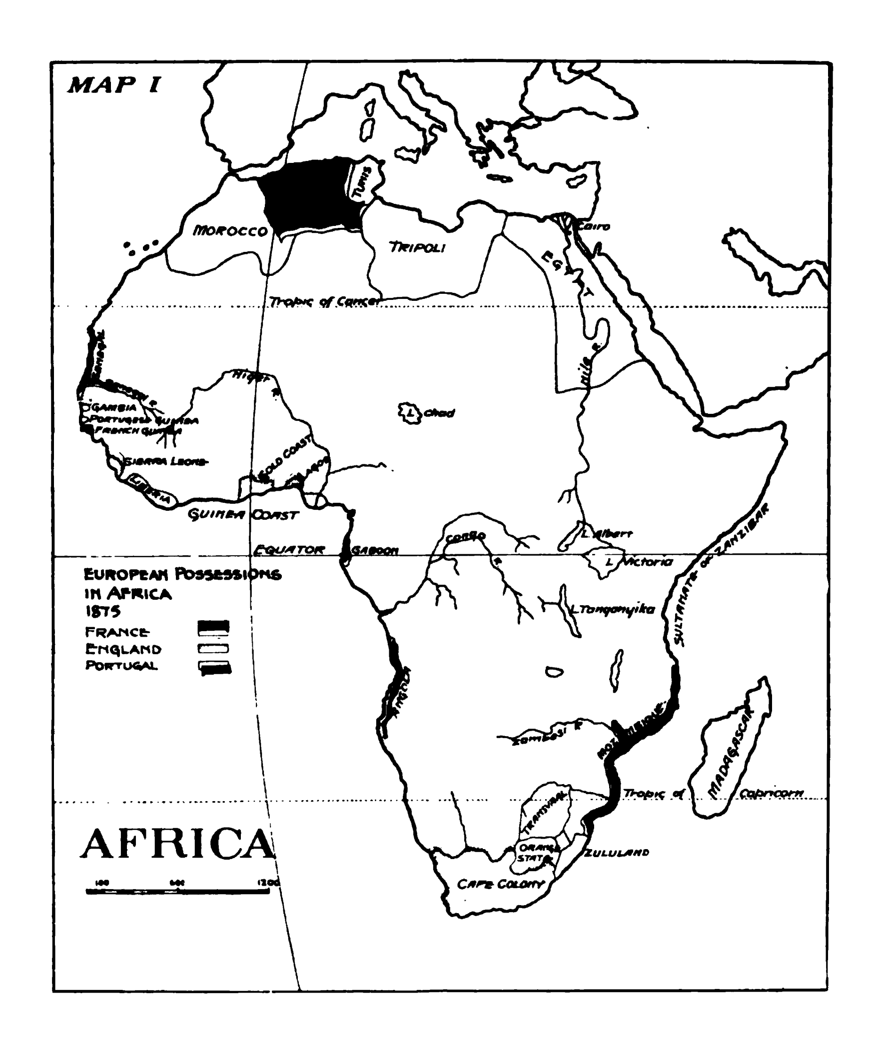
Theoretically, an income tax with a real-estate tax, as in New Zealand, would meet all cases. Practically, the general income tax cannot well be established in the United States. For us it should be a state system and not a national system; but if the income tax does not prevail some especial forms for reaching corporate property would be necessary in order to supplement the loss on personal property and improvements.

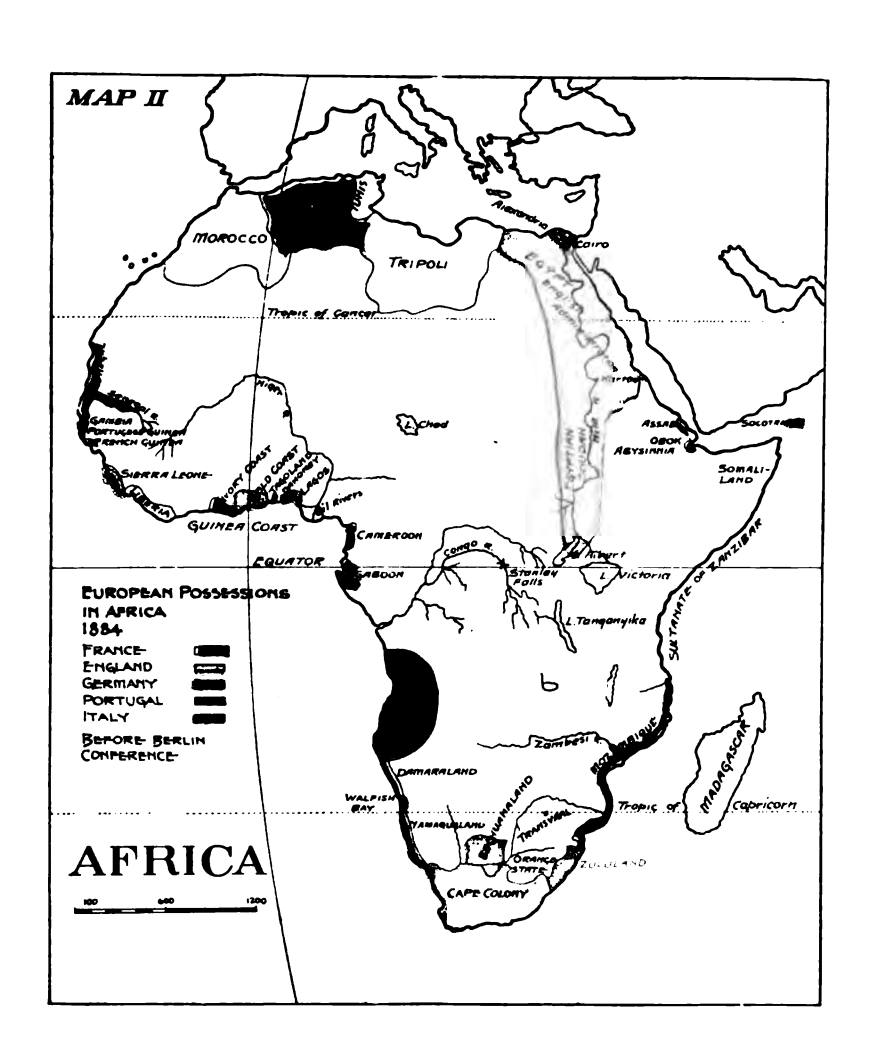
The inheritance tax is a means of obtaining revenues which seems to commend itself to the states in the union, as it is being adopted by one after another. They began by taxing collateral inheritances, and later direct inheritances. The only great virtue of this tax is that it is easy to assess and collect and seems to hurt nobody. That is the only justification it seems to have. However, if it became general much care would be necessary in some cases. For instance, a case where father, mother and sons had labored to develop a property, and the father dies, the property passing into the hands of the mother and sons. It would be an injustice to charge them an inheritance tax upon their own property which they had helped to earn. Hence, like other taxes, it has its own difficulties. It would have no need for existence had we rational systems of taxation outside of it.

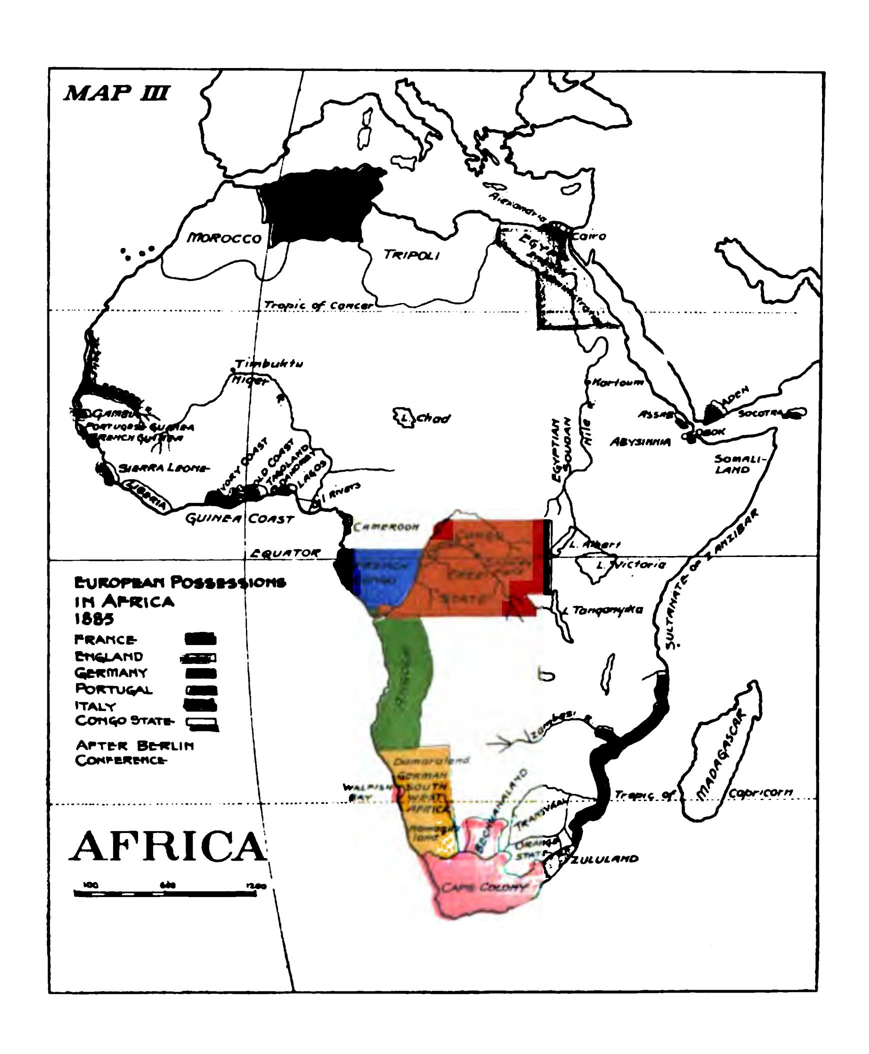
The franchise tax must be advocated as a means of justice to the

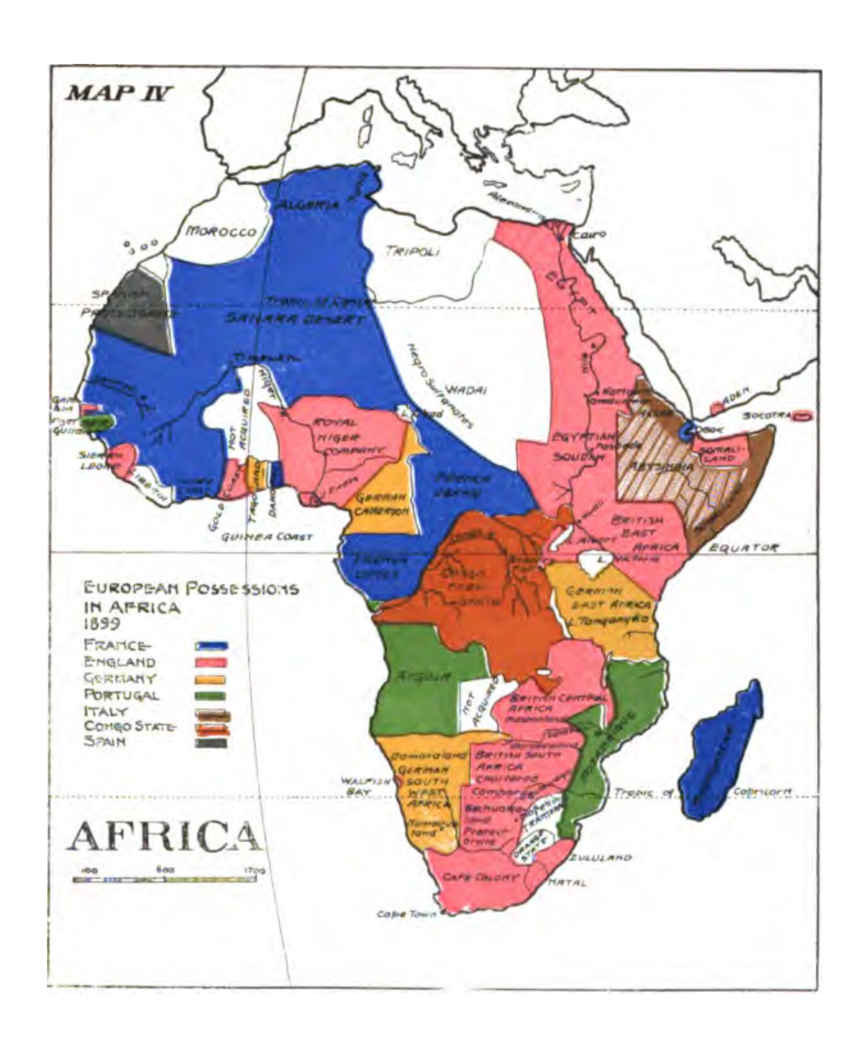


people. Certain it is if the property of the people is voted to a few for special purposes, to the exclusion of the many, the few should pay a special tribute to the many for that privilege; so that the franchise tax should not be abandoned even in the case of the income tax. There should be a payment for the special privilege over and beyond the payment on the income of ordinary business.


MAP I
MOROCCO
TUNIS
TRIPOLI
Cairo
EGYPT
Tropic of Cancer
Niger R.
L. Chad
Nile R.
GAMBIA
PORTUGUESE GUINEA
FRENCH GUINEA
SIERRA LEONE
LIBERIA
GOLD COAST
LAGOS
GUINEA COAST
EQUATOR
GABOON
CONGO R.
L. Albert
L. Victoria
L. Tanganyika
SULTANATE OF ZANZIBAR
ANGOLA
Zambesi R.
MOZAMBIQUE
MADAGASCAR
Tropic of Capricorn
TRANSVAAL
ORANGE STATE
ZULULAND
CAPE COLONY
EUROPEAN POSSESSIONS IN AFRICA 1875
FRANCE
ENGLAND
PORTUGAL
AFRICA
1200


MAP II
MOROCCO
TUNIS
TRIPOLI
Alexandria
Cairo
Tropic of Cancer
L. Chad
ASSAB
OBOK
ABYSSINIA
SOCOTRA
SOMALI-LAND
SIERRA LEONE
GUINEA COAST
CAMEROON
EQUATOR
GABOON
Stanley Falls
L. Victoria
L. Tanganyika
SULTANATE OF ZANZIBAR
EUROPEAN POSSESSIONS IN AFRICA 1884
FRANCE
ENGLAND
GERMANY
PORTUGAL
ITALY
BEFORE BERLIN CONFERENCE
Zambesi
DAMARALAND
WALFISH BAY
TRANSVAAL
ORANGE STATE
ZULULAND
CAPE COLONY
MADAGASCAR
Tropic of Capricorn
AFRICA


MAP III
MOROCCO
TRIPOLI
Alexandria
Cairo
EGYPT
Tropic of Cancer
Timbuktu
Niger
L. Chad
Kartoum
EGYPTIAN SOUDAN
Nile
ASSAB
ADEN
SOCOTRA
OBOK
ABYSINNIA
SOMALI-LAND
GAMBIA
PORTUGUESE GUINEA
FRENCH GUINEA
SIERRA LEONE
LIBERIA
IVORY COAST
GOLD COAST
LAGOS
Oil Rivers
GUINEA COAST
CAMEROON
EQUATOR
FRENCH CONGO
CONGO FREE STATE
L. Albert
L. Victoria
L. Tanganyika
SULTANATE OF ZANZIBAR
EUROPEAN POSSESSIONS IN AFRICA 1885
FRANCE
ENGLAND
GERMANY
PORTUGAL
ITALY
CONGO STATE
AFTER BERLIN CONFERENCE
Zambesi R.
MADAGASCAR
Tropic of Capricorn
Damaraland
GERMAN SOUTH WEST AFRICA
WALFISH BAY
BECHUANALAND
TRANSVAAL
ORANGE STATE
ZULULAND
CAPE COLONY
AFRICA
100
600
1200


MAP IV
MOROCCO
ALGERIA
TRIPOLI
SAHARA DESERT
SPANISH PROTECTORATE
Niger
NOT ACQUIRED
ROYAL NIGER COMPANY
GERMAN CAMEROON
GUINEA COAST
GOLD COAST
WADAI
Negro Sultanates
L. Chad
Alexandria
Cairo
EGYPT
Nile
EGYPTIAN SOUDAN
ADEN
SOCOTRA
SOMALI-LAND
BRITISH EAST AFRICA
L. Albert
EQUATOR
GERMAN EAST AFRICA
L. Tanganyika
EUROPEAN POSSESSIONS IN AFRICA 1899
FRANCE
ENGLAND
GERMANY
PORTUGAL
ITALY
CONGO STATE
SPAIN
NOT ACQUIRED
BRITISH CENTRAL AFRICA
Damaraland
GERMAN SOUTH WEST AFRICA
BRITISH SOUTH AFRICA
WALFISH BAY
Tropic of Capricorn
Bechuana-land Protectorate
ORANGE STATE
ZULULAND
CAPE COLONY
NATAL
Cape Town
AFRICA
1700

